

AN
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ON THE
U S E F U L N E S S
O F
C H E M I S T R Y,
AND ITS
A P P L I C A T I O N
T O T H E
V A R I O U S O C C A S I O N S O F L I F E.

TRANSLATED FROM THE ORIGINAL OF

SIR TORBERN BERGMAN,

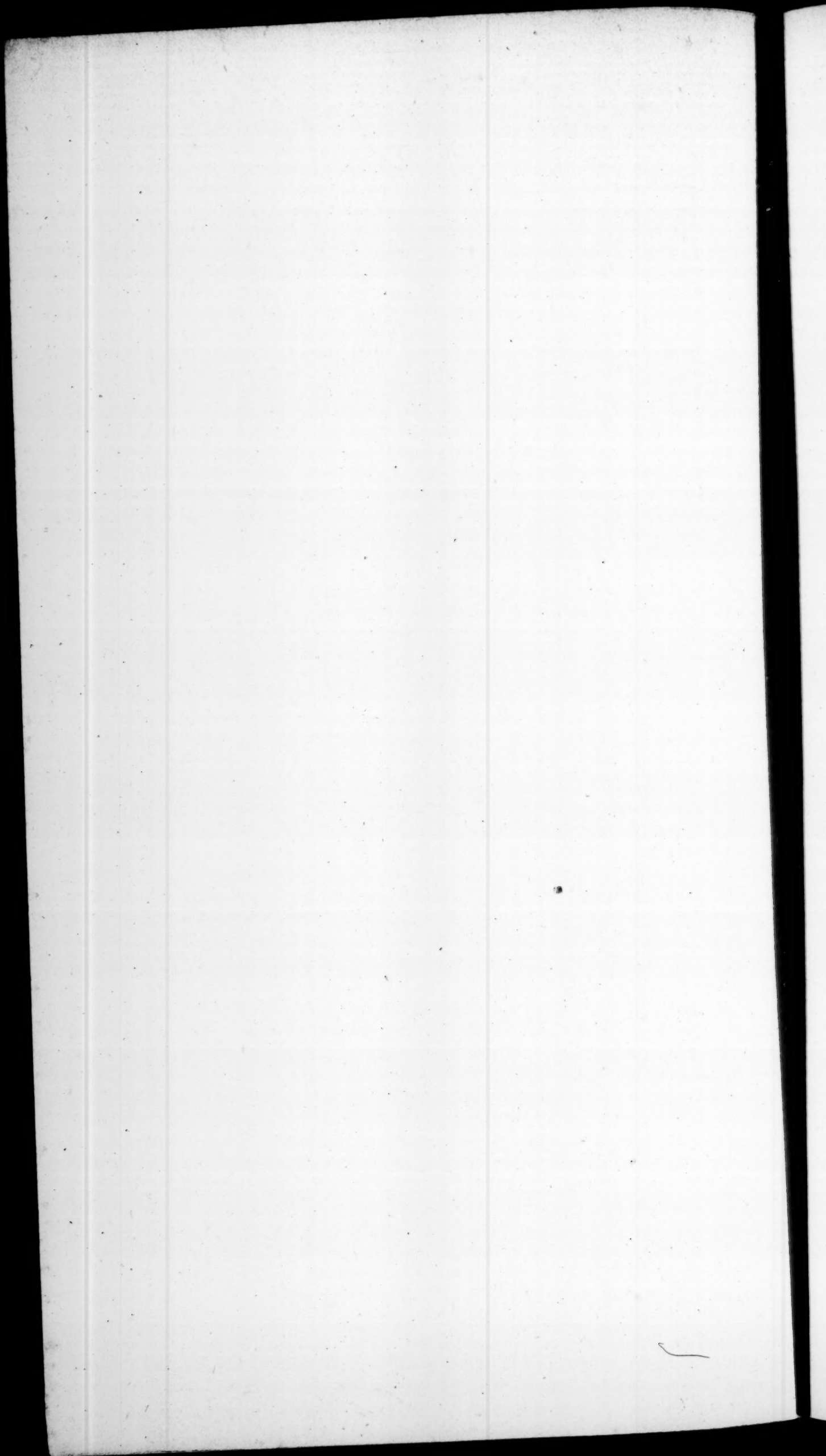
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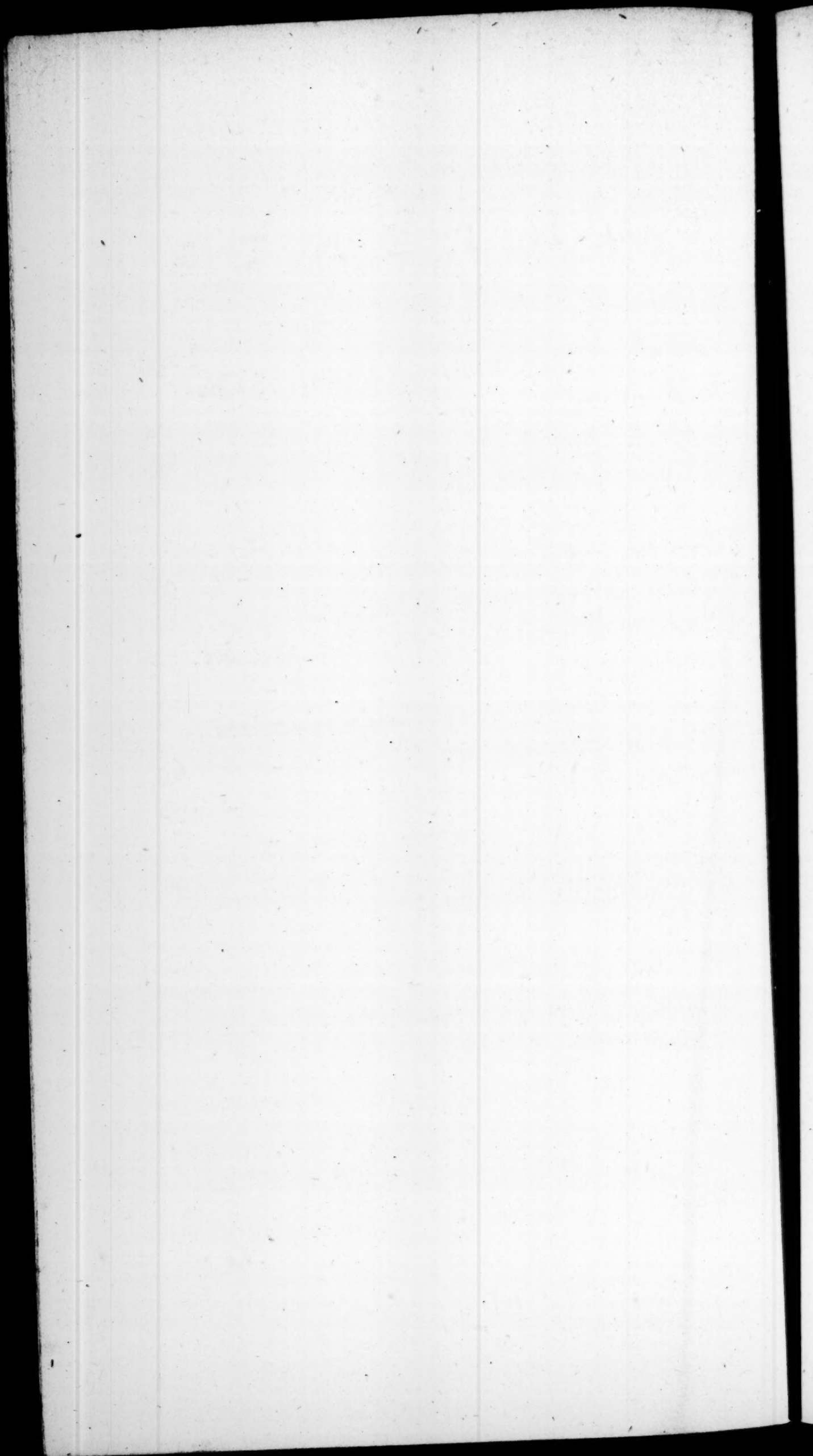
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GENERAL VIEW

O F

CHEMISTRY.

I.

UNDER the appellation of natural knowledge, taken in the most extensive signification of the phrase, is comprehended, whatsoever knowledge we have acquired of the nature of bodies, whether by observation or experiment. This branch of science, in its progress towards perfection, may be considered as passing through three successive stages; dividing itself, as it were, into so many different sciences, which are commonly
B spoken

2 GENERAL VIEW

spoken of as distinct, although the limits of them are, in certain cases, very ambiguous and difficult to ascertain.

II.

The first of these is called NATURAL HISTORY: the business of which is, by an attentive scrutiny, to enquire into the superficial appearances exhibited by natural bodies, especially their external form; to find out in them, as often as it can be done, certain characteristic marks, by which any one of them may, at all times, be distinguished from every other. The notice therefore which a natural historian, or naturalist as he is called, takes of a plant, for example, is of this sort: he observes [by the help of characteristics previously ascertained] what genus, species, and variety it belongs to. He observes, whether it is found most commonly growing in an open spot exposed to the sun, or in the shade; at what season it flowers; whether it turns itself or not to the sun; whether the

the flower opens itself or not at a certain hour of the day, &c. &c.

III.

NATURAL PHILOSOPHY [or mechanical philosophy, as it might be called in contradistinction to chemistry] penetrates farther into the interior nature and essence of bodies; calls in the assistance of experiment, for the purpose of investigating their general properties, and ascertaining the laws, or general rules, according to which they operate. For which purpose the natural philosopher, not content with observing the appearances they exhibit when left to themselves, interrogates nature still more closely; and exercises his invention, by putting them into a variety of new and artificial situations. Let us observe (still pursuing the same example) in what light a man, who cultivates this branch of science, considers a plant: he investigates the quantity of its transpiration by a balance; he traces out its chyliiferous ducts,

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by means of coloured liquors ; he tries the influence of light upon its health and colour, by putting it into the dark, &c. &c.

IV.

In the third and last place comes CHEMISTRY ; which, not content with investigating the properties of bodies, traces out the causes of those properties, by examining into their ingredients and composition. Thus, (pursuing the same example) upon examining a plant after the manner of a chemist, a man learns how much salt, oil, water, earth, and so forth, are contained in it ; and further, to which of its parts the smell, taste, and other properties and virtues of it, are owing.

V.

CHEMISTRY is therefore that science, which examines the constituent parts of bodies with reference to their nature, proportions, and method of combination.

VI.

VI.

The particles which are separated from one another by the chemical analysis, or decomposition of a body, are called its *principles, elements, or constituent parts.*

VII.

There are, accordingly, two methods of dividing bodies, a mechanical and a chemical; to which correspond so many different sorts of elements, or constituent parts.

VIII.

*Mechanical elements, or parts, are each of them of the same nature as the whole, and are distinguished from it no otherwise than by their bulk: thus, upon powdering a piece of chalk, it is reduced to a multitude of smaller pieces, each of which is a mechanical part, or element of the whole. These are also called *integrant parts.**

6 GENERAL VIEW

IX.

Chemical elements is the name given to parts of different natures, which, being put together, unite into one body. Thus calcareous earth or lime, aërial acid and water, are the chemical elements of chalk.

X.

As the elements into which a body is resolved by chemistry in the first instance, are seldom in the most perfect state of simplicity, different orders of elements may accordingly be conceived.

XI.

Those elements, into which, by chemistry, a body may be resolved in the first instance, may be termed its proximate principles or elements: such are sulphur or brimstone, and mercury or quicksilver, with respect to cinnabar.

XII.

XII.

By decomposing again each of those *proximate* principles of cinnabar, one may attain its *remote* principles: [which again may be considered as proximate principles with reference to the former set.] Thus the proximate principles of brimstone are phlogiston and vitriolic acid; of quicksilver, phlogiston again, and the metallic calx of quicksilver; accordingly, vitriolic acid, phlogiston, and quicksilver, are the *remote* principles of cinnabar.

XIII.

If the principles, into which a body has been thus resolved, are capable of no further resolution, they may be called primary, or ultimate principles or elements.

XIV.

The division or resolution of a body into its principles or elements, is termed che-

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mical analysis; as the putting together of bodies of the same sorts as those principles, so as to make up a body of the same sort as that so analysed, is termed chemical synthesis.

XV.

It is then only we can be sure of our knowing what the real constituent parts, or elements of a body are, when the analysis and synthesis of it tally with each other.

XVI.

The nature of a body depends, not only on the *nature* of its elements, but likewise on the *proportion* in which they are found in it, and the manner in which they are connected. Common field marle contains the same elements as the topaz; at the same time the properties of these two bodies are altogether different.

XVII.

XVII.

The cohesion that takes place between the elements of a body, depends upon the force with which they attract one another, and is proportioned to that force.

XVIII.

All bodies in nature have an attraction for each other.

XIX.

In the heavenly bodies this attraction exerts itself according to one simple law; but among the small bodies which compose our globe, this force is different, according to the different nature of those bodies.

XX.

If three different particles, A, B, and C, meet together, and two of them unite in such a manner as to exclude the third, this is called simple elective attraction.

XXI.

XXI.

If A, being united with C ; afterwards, upon B's being applied to them, unites with B, and lets go C ; A is said to possess a greater attraction for B than for C : thus, if you pour vitriolic acid upon common salt, it is found, that the mineral alkali of the salt has a greater attraction for the vitriolic acid, than for the marine acid, with which it was before combined, as it leaves the latter, and unites with the former. The vitriolic acid is also said to have a stronger attraction for the mineral alkali, than the marine acid has ; and, accordingly, the former acid is said to expel the latter acid from its basis.

XXII.

The relations thus subsisting among a number of substances, are, for the sake of conciseness and convenience of inspection, represented by placing the names of those

6

substances

substances (expressed by peculiar characters) one above another, in columns; and a number of such columns put together, compose what are called tables of attraction or affinity.

XXIII.

The attractive forces which any greater number of bodies than three, upon meeting, exert one upon another, is called compound attraction; and, in particular, when four bodies operate upon one another in this manner, at the same time, double attraction.

XXIV.

When two substances are united together, no third substance added to them will effect a separation between them, unless such third substance has a stronger attraction for one of them, than the other has. When pure calcareous earth is dissolved in nitrous acid, caustic volatile alkali alone will not separate them, because

because the attraction of the alkali for the acid, is not so strong as that of the calcareous earth is.

XXV.

But what cannot be done by a third substance alone, is often effected by that in conjunction with a fourth: thus, to the pure *calcareous earth*, as in the foregoing example, let aërial acid be added, and the separation is effected: the aërial acid acting upon the calcareous earth on the one hand, at the same time that the alkali acts upon the nitrous acid on the other, diminishes the cohesion of the earth with the nitrous acid to such a degree, that the volatile alkali is now able to unite itself to the latter acid, and expel the earth.

XXVI.

To the exertion of these two sorts of attractions, simple as well as double, fluidity is necessary on the part of some one, at least, of the substances concerned. But
this

this fluidity is susceptible of two different forms, according to which attractions are said to be exerted in so many different ways, which are called the humid way and the dry.

XXVII.

It is called the humid way, when one of the substances, at least, is fluid in the heat of the atmosphere, or at least in a heat not much greater than that of the atmosphere; and this is the case in the several examples above-mentioned.

XXVIII.

It is called the dry way, when, in order to produce the necessary degree of fluidity, substances (while as yet in a dry state) are exposed to a considerable degree of additional heat: for instance, by the application of burning fuel. Thus, if cinnabar be mixed with iron filings, and a certain degree of heat be applied, the quicksilver of the cinnabar will rise up, leaving the
brimstone

brimstone (which is the other element of the cinnabar) combined with the iron; the brimstone attracting the iron stronger than it does the quicksilver. This is a case of simple attraction. Again, if *hydrargyrum vitriolatum* [quicksilver united with the acid of vitriol] be mixed with *alkali minerale salitum*, [common salt] and a certain degree of heat is applied, a new combination takes place among the substances concerned, in virtue of a double elective attraction: the marine acid of the common salt unites itself with the quicksilver of the mercurial salt, forming a new mercurial salt, called corrosive sublimate [*hydrargyrum salitum fortius*]; while the mineral alkali of the common salt combines with the vitriolic acid of the first mercurial salt, forming what is called Glauber's salt.

XXIX.

The whole system of these set of *elective* attractions, double as well as single, may be represented in the most commodious manner, so as to be comprehended at a
single

single glance, by the tables above-mentioned [f. 22]; by means of which the whole theory of attractions, which forms so important a branch of chemistry, is placed in a very intelligible point of view.

XXX.

Since then all chemical operations are reducible to analysis or synthesis, that is, to discombination, as it may be called, and recombination of substances; and as these operations depend upon the laws of this species of attraction, it appears that the knowledge of these laws must be, as it were, the key to the whole science.

XXXI.

Chemistry, in so far as it applies itself to throw a light upon the general course of nature, and the causes of the several phenomena exhibited by bodies, may be termed

[*chemia*

[*chemia pura*] pure, general, or philosophical chemistry.

XXXII.

But when it enters, more or less, into details, and applies itself to use, by teaching us, partly, how the several sorts of bodies, according to their respective natures, may be employed, when at hand, in the most advantageous manner, to the several purposes of life; partly how they may be preserved and ameliorated, or even, if not at hand, how they may be prepared; it may be termed [*chemia applicata*] mixt, particular, or popular chemistry, after the same manner that mathematics is denominated in the like cases.

XXXIII.

Chemistry, like mathematics, may also be distinguished into [*chemia vulgaris*] vulgar or elementary chemistry, which concerns itself only with the grosser and
more

more palpable elements of bodies; and [*chemia sublimior*] transcendental chemistry, which, not neglecting the grosser and more palpable elements, finds means, by particular contrivances of its own, to collect and examine those elements of finer texture, which otherwise, in consequence of a degree of subtlety which renders them imperceptible to our senses, would fly off and escape our notice. These finer elements may be considered, in some respects, as corresponding to the fluxions and infinitesimals of the sublimer or transcendental geometry.

XXXIV.

The transcendental chemistry requires particular talents, as well for the devising as for the executing of such experiments as are best calculated to bring forth the truth with certainty. Since the rapid strides which chemistry has made within these last twelve or fifteen years, it is become abundantly evident, how imperfect

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the

the knowledge of those persons must be, who chuse to confine themselves to vulgar chemistry. But it is not to be wondered at, if men, who possess neither the talents nor patience necessary to such nice enquiries, should seek to palliate their own deficiency, by flighting them under the name of subtleties. Mean time, that a substance which oftentimes constitutes a great part, even as far as half the weight and, sometimes more, of the body in which it is found, is an object not worth attending to, and which as such may be thrown away, or suffered to escape unheeded, is a proportion which cannot but appear to be rather an extraordinary one. In fact, a man who considers nature with ever so little attention, cannot surely help being aware, that every thing that we see happens in conformity to certain laws; and that the smallest circumstances have their causes, as well as the greatest. In the system of nature every phenomenon is connected with every other; insomuch that we may be warranted in saying, that
in

in this branch of science, either there are no such things as subtleties, or that here even subtleties themselves are not to be contemned.

XXXV.

As we are continually employing the different substances in nature in subservience to our different necessities, there needs not much profound study to apprehend, in a general way, the use of that science, the business of which it is to investigate those circumstances in the composition of bodies, on which their various differences are grounded. However, in order to give a more detailed and particular view of its utility, it may be proper to distinguish popular chemistry into various subordinate branches, and to bestow on each of them a separate consideration.

XXXVI.

There are but three respects, in which the several sorts of bodies which we are

20 GENERAL UTILITY

conversant with, can be made subservient to our use; *viz.* in respect to our health, in respect to our maintenance, and in respect to the pleasures and conveniencies of life.

XXXVII.

Accordingly, popular chemistry may be divided, in the first instance, into three branches; the medical, the œconomical, and the technical.

MEDICAL CHEMISTRY.

XXXVIII.

The objects of medical chemistry are such substances as are capable of being made conducive to our health. But, as the ways in which they may be made subservient to that purpose are different, this

this branch of chemistry is accordingly susceptible of a number of subdivisions; all which may here be mentioned, though the nature of this design admits not of their being considered otherwise than in a very general point of view.

XXXIX.

Medical chemistry has naturally two objects in view: to wit, first, the knowledge of the chemical properties of the living body, to the health of which it proposes to be subservient; and, secondly, of the several other substances which are of a nature to contribute, more or less, to that design.

XL.

The first of these divisions constitute what may be termed physiological chemistry. The business of this branch is, in the first place, to lay open the texture and composition of the several solid as well as fluid substances of which the body, as

well in a healthy as in a morbid state, is composed: in the next place to explain the several chemical processes, which are going on in every part of the body: such as digestion, preparation of chyle, of blood, of gall, of the pancreatic juice, &c.

XLI.

This branch is as yet but in its infancy; although, on the one hand, the cultivation of it cannot but be of the greatest advantage to medicine; and, on the other hand, the neglect of it has given admission to a great part of that prodigious variety of absurd positions, with which that science has hitherto been overwhelmed. One example will be sufficient: entire works have been written on the production of the stone in the bladder from calcareous earth, although the most exact analysis cannot discover in it, upon an average, above one part in a hundred of this earth. One may judge by this, how well grounded many of the expedients have been, which
we

we have seen proposed for the dissolving of the stone.

XLII.

The other principal branch respects the knowledge of the chemical properties of the several substances, which are found to be beneficial or noxious to health. This may be comprehended under the name of *pharmaceutical chemistry*.

XLIII.

This branch comprehends again other branches of science, which it may be of use to distinguish from one another.

XLIV.

To this head belongs, in the first place, the knowledge of the constituent parts or elementary ingredients of the several bodies which are made use of, whether for the purpose of medicine or of nourishment. The substances we are taking in

continually in the way of diet, produce not such quick and remarkable changes in the body as medicines do : however, at the long run, the influence of the former on our health is too evident to admit of their being excluded from consideration in the present instance.

XLV.

It is further necessary to understand how to separate the useful parts of those substances, from such useless or pernicious ones as they may happen to be encompassed with ; also how the useful parts, so separated, may be prepared, as well each of them by itself, as any number of them together ; in such manner, as that they may possess the least unpalatable, and the most commodious form. This branch commonly goes by the name of pharmacy : it supposes great extent of knowledge, if regarded, as it ought to be, upon the footing of a science.

XLVI.

XLVI.

As to water and air, although what concerns the properties of these two substances might be properly enough ranked under a former division [f. 44]; yet, as they are of such necessary and extensive use, they may seem, on that account, to claim each of them a separate consideration.

XLVII.

The business of the *hydrological* branch of chemistry will accordingly be, to investigate the nature of the several sorts of waters, with regard to the several heterogeneous substances which they are apt to contain, and to which all the differences which are observable in them are owing.

XLVIII.

This branch of the science affords us then an effectual set of expedients, for imitating by art all such naturally impregnated

nated waters as are valuable enough to be worth the trouble : which may be the case, either on account of their not being to be had at all in the places where they are wanted, or not at so low a price as they may be made for.

XLIX.

Water has more or less to do with almost every thing we eat; and forms the greatest part of every thing we drink: the different impregnations which this substance is apt to receive, cannot therefore but be of some consequence, more or less, upon every occasion.

L.

The *aërological* branch, the business of which is to investigate the nature and properties of the different kinds of air, is not less interesting than that last mentioned. On every side we are surrounded with this element, in which we live as fishes do in water. The different modifications

cations of which it is susceptible, not only have a very considerable influence upon perspiration, that process so intimately connected with our health, but are also indispensably necessary to the continued motion of the lungs, those bellows by which the flame of life is kept alight. It is not enough that they are kept distended by any kind of elastic fluid. A certain quantity of a particular kind of elastic fluid is necessary for this purpose. Of this quantity, that part which is perfectly pure, and which of itself is the only part that is fit for respiration, makes always but a small proportion, and seldom more than a fourth part, of the whole atmospheric mass; the rest is altogether unfit, and, of itself, would extinguish life in a few moments.

LI.

The state of the air is not only very different in low and elevated situations, in open places, and close rooms; but even in the same room, it is scarce every where exactly

exactly alike: it is therefore of no small importance to be informed of these inequalities, which, as far as concerns fitness for respiration, may be pretty exactly measured by the new-invented instrument, called the *Eudiometer*.

LII.

Thus much is enough to show, that, without the help of chemistry, the art of medicine cannot but fall very far short of its perfection.

ŒCONOMICAL CHEMISTRY.

LIII.

In rural œconomy there are several processes, which, in order to succeed under all circumstances, stand in need of receiving more or less light from chemistry: some of
the

the principal of these we shall here enumerate.

LIV.

In a general view, this branch of business may be said to have two objects: in the first place, to produce certain substances in the state of raw materials; in the next place, so to deal with them, as to turn them to the best advantage.

LV.

Raw materials, from the vegetable kingdom, which are the objects of rural œconomy, are all sorts of grains, roots, and fruits, stalks and leaves of herbaceous plants; such as hay, flax, hemp, &c. In milder climates grapes, olives, &c.

LVI.

All these several articles, in order to be produced in perfection, require each of them its proper and peculiar management: a proper kind of earth must be procured
for

for them, or the earth that is at hand must be rendered so by art, if the husbandman would be rewarded for his labour.

LVII.

Besides the earth in which they grow, vegetables must be supplied with matters proper for their nourishment; and in particular with such as are calculated to constitute their solid parts. But these, in order to be carried up through the roots, require the assistance of water, being the vehicle which is the best adapted to this purpose.

LVIII.

A good earth must therefore contain, in the first place, a sufficient quantity of nutritive materials; and, besides, a sufficient quantity of water, to serve as well in the way of nourishment as in the capacity of a vehicle, for the nourishment that may be afforded by other substances.

LIX.

LIX.

The mineral earths which are most commonly found in the common soil are clay, sand, and calcareous earth; with which are intermixed a greater or less quantity of vegetable substances, which, as they putrify, lose their organical texture.

LX.

Of these three earths there is not any one which, by itself, is fit for the support of vegetables. In a good soil they are therefore always found mixed, at least two of them together.

LXI.

Clay retains water the longest; after clay, calcareous earth; sand dries the quickest. Hence it follows, that from the different proportions in which they may be mixed, result so many differences with regard to their capacity for retaining water.

On

On this occasion the inferior strata require to be considered as well as that which forms the surface of the ground.

LXII.

The best earth being barren, and, as it were, lifeless, without water, it is obvious, that that mixture is the best, which is best adapted to the mean state of the weather, with respect to drought and moisture: unusual accidents are not to be prevented by human foresight.

LXIII.

But the influence of *situation* is such, that the same mixture in different places has different effects. The business is therefore to find out that mixture, which is best suited to the situation of the spot.

LXIV.

If the farmer then knows how to distinguish the different kinds of earth in his grounds,

grounds, and to judge of the proportions in which they are mixed, in the same manner nearly as a miner judges of the contents of his mines; he may, by due observation and reflection, be able, in the course of a few years, to determine what mixture is best suited to his situation.

LXV.

To grow corn in a field, and to produce it in the greatest possible quantity, are two very different things; the former may be compassed without any very great stock of knowledge; but by no means the latter, unless perhaps by great chance.

LXVI.

The uses which chemistry may be of in agriculture are very considerable; but the limits of this design will not allow of our doing any thing more, than just to mention the principal of them in a few words. To chemistry it belongs to distinguish the different kinds of earth, according to
D their

their natures and proportions; to determine which of them are the fittest for different purposes; to ascertain the different qualities of the various sorts of manures; and to point out proper methods of applying them; to produce them in such quantities as may be required; to ascertain the best method of improving a poor soil; to effect, by a mixture of earths, what is not to be done by manure alone.

LXVII.

Agriculture, that most honourable and ancient of professions, has scarcely since the time of the Romans received any essential improvements. The reason is, not that it is already at its perfection, but that a sufficient stock of natural knowledge has never been hitherto applied to it. The great object has been to make fields look like the flower-beds in a garden; but then the field ought to be as easy to water as a garden, or a man will find the impropriety of this method to his cost.

LXVIII.

LXVIII.

When the productions of agriculture are at length obtained, the aid of chemistry is still as much wanted as ever, for the purpose of preserving and improving them.

LXIX.

Brewing, baking, making brandy, cyder, wine, and vinegar, are all of them so many chemical processes; which, for want of the requisite stock of knowledge, in many cases, either fail altogether, or are carried on with little profit. To this head likewise belongs the preparation and preservation of yeast, or leaven.

LXX.

Other useful branches of rural œconomy, are those that concern the preparation and production of syrups from the different substances which afford a saccharine

D 2

matter;

matter ; the preparation of starch : also that of flour and gruel from potatoes, &c.

LXXI.

To prepare flax and hemp in such a manner as to yield the finest, strongest, and softest threads ; to bleach linen, so as to give it the purest white, without losing its strength ; to preserve wood from putrefaction ; to enable wainscot and paperhangings to resist the fire &c ; are so many problems, which can look only to chemistry for their solution.

LXXII.

From the animal kingdom the farmer collects raw materials, such as eggs, meat, tallow, wool, hair, feathers, hides, milk, honey, wax, &c. many of which by chemical art, if necessary, may be preserved uncorrupted for a considerable length of time, or may even, in some instances, be restored

restored in good measure to a sound state, after corruption has begun to take place.

LXXIII.

By the improvement of the raw materials, are obtained butter, cheese, sugar, yarn, flax, thread, packthread, cordage, and many other articles, by processes which may be carried on with much greater facility and success, if the chemical nature and properties of the several materials be understood.

LXXIV.

Further instances, in which the farmer may occasionally find a considerable advantage by understanding chemistry, will appear under the head next ensuing.

LXXV.

A multitude of processes, which sometimes are carried on in the small way in families, at other times, being carried on

in the large way, constitute the business of so many separate manufactories, or professions; and may, on this account, be referred to the head of *technical chemistry*.

TECHNICAL CHEMISTRY.

LXXVI.

The application of chemistry to arts and manufactures is of very great extent: some of them are nothing but a chain of chemical processes from beginning to end; others belong, in certain stages of their progress, principally to mechanics, but at the same time require the assistance of chemistry at certain other periods.

LXXVII.

LXXVII.

This being premised, technical chemistry may, in conformity to the chemical arrangement of bodies, be divided into five branches, viz. first, *balurgic chemistry*, or that which relates to salts; secondly, *geurgic*, or that which relates to earths; thirdly, *theiurgic*, or that which relates to sulphureous bodies; fourthly, *metallurgic*, or that which relates to metals; fifthly, *opificiary* (*b*), or that which relates to the several sorts of arts and manufactures.

LXXVIII.

Arts and manufactures were, for the most part, in their origin the work of chance; and since then receiving improvement by continual and successive trials, have been brought to the degree of perfection at which we see them now; commonly, without being obliged to science

(*b*) See 144.

D 4

for

for their advancement. But this is no proof, but that the success of them is founded on certain chemical truths or axioms, on certain general facts, which it comes under the province of chemistry to teach and to explain; and on account of which, it consequently cannot but receive considerable light from chemistry: some it has received already, and doubtless it would have received much more, had it not been for that veil of mystery, with which private interest naturally seeks to cover those lucrative employments.

LXXIX.

It is the business of the *balurgic branch* of chemistry, to teach the art of preparing and purifying the several sorts of salts. [See sections 162 to 191.]

LXXX.

To this head therefore belongs the preparation of the mineral acids, of which number those for which there is the greatest

est demand in trade, are ; first, that which is made from vitriol or sulphur, the vitriolic ; secondly, that which is made from salt-petre, or, as it is otherwise called, nitre, the nitrous ; thirdly, that which is made from common salt, the marine, or muriatic. Of vegetable acids, that of vinegar is the only one which is prepared in the large way ; the preparation of the others being confined to chemical laboratories, and apothecaries shops.

LXXXI.

The fixed alkalis, such as that of potash and that of soda, are articles of trade. Volatile alkali is mostly prepared in apothecaries shops.

LXXXII.

Of the neutral salts, including as well those which are perfectly saturated [see 183] such as Glauber's salt, salt-petre, common salt, and sal ammoniac [see 184] as those which are supersaturated, such as
tartar

tartar and borax [see 185] those here mentioned are prepared and purified in the large way; the others for the most part only in apothecaries shops.

LXXXIII.

Sugar may be considered as a kind of vegetable essential salt, of which, in our times, a considerable quantity is consumed. The art of refining it is still capable of receiving many lights from chemistry.

LXXXIV.

Of the earthy compound salts [see 188], which occur in trade, nature herself prepares gypsum [see 200]; as also, in some places, the sal amarum [see 202]; but alum is solely produced by art [see 204].

LXXXV.

The metallic compound salts which occur in trade, are all of them prepared by art. The principal of them are, first, blue vitriol,

vitriol, or vitriol of copper ; fecondly, green vitriol, or vitriol of iron ; thirdly, white vitriol, or vitriol of zinc ; fourthly, corrosive fublimite, or mercury combined with marine acid ; fifthly, faccharum faturni, or vinegar combined with lead ; and fixthly, verdigreafe, or vinegar with copper.

LXXXVI.

In the preparation of many of thefe falts, many important improvements have been made in our own times by the means of chemiftry ; and, in particular, we are now able to obtain the mineral acids with much lefs trouble, as well as expence, than formerly ; and there is the greateft reafon to hope, that more and more improvements refpecting the preparation of thofe fubftances will be difcovered.

LXXXVII.

The geurgic branch of chemiftry comprehends all the preparations, of which
any

any kind of earth constitutes the principal ingredient. The calcareous, argillaceous, and filicious earths are employed, not only in agriculture, but to several other purposes.

LXXXVIII.

Calcareous stones are burnt; whereupon, if water is poured upon them, they fall into a powder, which is the principal ingredient in the mortar used for walls. If it be mixed with a little Manganese [see 259] it forms black chalk, which is found particularly useful in such mason's work as is done under water.

LXXXIX.

It is from chemistry that we learn the nature of the change which chalk undergoes upon being burnt: viz. that a quantity of aërial Acid and water, amounting together to a little more than half its weight, escapes from it, and that a certain quantity of the matter of heat is set at
6 liberty

liberty [see 297]. Thus informed, we have not only obtained just notions respecting the properties of this earth, but we are also enabled to lay down rules, with more exactness than before, for burning and extinguishing it, for preserving its properties unimpaired, and for employing it to the best advantage.

XC.

Argillaceous earth, or Clay, when prepared with a certain quantity of water, possesses a degree of tenacity, which renders it fit to be moulded into various forms. Upon being baked, it contracts considerably, and is apt to crack, if it is not mixed with a sufficient quantity of sand. Not only this mixture, but clay by itself, acquires a very considerable degree of hardness in the fire. In virtue of these properties, a variety of useful articles have been made out of it, differing from each other in respect of the goodness of the materials, the nicety of the workmanship, and

and the beauty and convenience of the form.

XCI.

Every one knows the use that bricks and tiles are of in building ; the former to compose the substance of the walls, the latter to form the covering of the roof.

XCII.

In regard to bricks, which are to be bedded in good mortar and covered with it all round, much nicety in the choice of the clay is not required ; it is enough if it be but equally worked throughout and well burnt ; but for those which are exposed to all the vicissitudes of the weather, a greater degree of nicety is required.

XCIII.

The purer the clay is, the better it is for bricks and tiles ; for since the purer it is, the more it contracts, it is therefore the
less

less disposed to receive water; which, in freezing, bursts the strata of particles which are contiguous to it, and, little by little, crumbles down the whole substance of the brick.

XCIV.

If there happens to be a little lime in the clay, tiles that are made of it, if burnt in the common way, are incapable of lasting long in the open air without a cover; for the calcareous particles, attracting moisture, are washed out, leaving holes; which, filling with water, form, as it were, so many little mines; which, as soon as a frost comes, explode and burst through the substance in which they are inclosed. This imperfection is obviated, by giving a vitreous coating to the surface; which is done by the force of fire, either alone, or assisted by a little common salt, which is strewed upon them in the kiln. This glazing pretty effectually answers the desired purpose.

XCV.

XCV.

For these and a number of other circumstances that occur in the arts of brick-making and tile-making, such effectual provision may be made by the help of chemistry, that thereby there is scarce any sort of clay but what may be made to serve.

XCVI.

Of common clay are likewise made a variety of the ordinary sorts of potters ware, as well glazed as unglazed.

XCVII.

Potters ware, when covered over with a kind of enamelled glazing, forms that particular kind which is called Delft ware.

XCVIII.

A kind of reddish brown clay, containing iron, is likewise made into a variety of utensils,

utenfils, for the moſt part unglazed; in which ſtate the earth is called by ſome *terra ſigillata*.

XCIX.

Clays, ſuch of them as are qualified to reſiſt the fire, are made into crucibles, muffles, retorts, and a variety of other veſſels uſed in chemiſtry.

C.

Veſſels made of the finer and apyrous, and perfectly opaque ſorts of clays, and which uſually are glazed, are called *ſtone ware*.

CI.

A white, ſemi-transparent apyrous earth, which ſtrikes fire with ſteel, forms, when incruſted with a glazing of chryſtalline earth, a kind of ware, which is called *porcelain*, or *true china*. To the compoſition of this ſubſtance there needs an apyrous clay, which by burning becomes white, and another earth, called in China pe-

E tuntſe,

tuntse, which serves to bring clay to a half-melted state, necessary to its semi-transparency.

CII.

Along with the purest clay there is always mixt a considerable quantity of siliceous earth; the more there is of this, the less it is necessary to add, in order to prevent the clay from cracking.

CIII.

Siliceous earth, brought into fusion by an alkali, forms the most common sorts of *glafs*.

CIV.

Glass may be made to receive various colours, by means of metallic calces mixed up with the other composition before it is reduced to fusion: glass thus coloured is called *Fluor*.

CV.

CV.

When the colouring additament is of such a nature as to deprive the glass of its transparency, the mass is called *enamel*.

CVI.

A mass of this sort, when white and semi-transparent, has been called *false porcelain*. Also the common bottle glass may be converted into a substance, which, in its appearance as well as its other properties, approaches very near to real porcelain: this is called, after its inventor, *Reaumur's porcelain*.

CVII.

All these different sorts of earthen ware, in order to be brought to perfection, require a considerable degree of knowledge as well as practice, as well with regard to the nature of the materials, as with regard to the method of mixing and working

E 2

them,

them, the degree of fire proper to be given them, &c. &c.

CVIII.

To the *Theiurgic branch of chemistry* belong such preparations as contain a considerable quantity of phlogiston. Of these, according to the different nature of the other ingredients, there are various sorts.

CIX.

Sulphur or brimstone [see 212] is applied to a variety of purposes: it is obtained by distillation from sulphureous pyrites.

CX.

The *phosphorus of urine* [see 215], which is likewise a kind of sulphur, has been applied hitherto to no other purpose than that of chemical experiment. It is still very dear; but, with proper materials and proper management, it may be made at very little expence.

CXI.

CXI.

From the seeds of several plants are obtained, by pressure, the sorts of oils that are called the *fat* [*unguinous*], or expressed vegetable *Oils* [see 229]. Some of them become dry by time, others not, and they are accordingly applicable to different purposes. There are likewise certain processes, by which they may be rendered fitter for their respective uses.

CXII.

From the animal kingdom expressed oils are obtained by melting [see 226]. *Spermaceti* is a fluid substance of this kind, which used to be obtained only from the brain of certain sorts of whales; but since a method has been found out of obtaining it from the common fluid oil extracted from those fish, the price of it is considerably fallen. *Spermaceti*, when purified, is the best substance to make candles of any that is yet known.

CXIII.

The expressed oils, as well animal as vegetable, combined with alkaline salts, form several sorts of *soaps*, which are of different fineness and goodness, according to the nature of the ingredients.

CXIV.

The *essential oils* [see 227] are obtained for the most part only by distillation; though some of them, such as the oils of oranges and lemons, are obtained by simple pressure. The principal of those that are prepared in the large way, are obtained from the Indian spices: they are all exposed to a number of adulterations. Chemistry, however, is able not only to discover the fraud, but frequently also to determine the quantity and quality of the spurious matter.

CXV.

CXV.

Sweet-scented waters are prepared from essential oils dissolved in spirits of wine.

CXVI.

Brandy, spirits of wine [see 233], and *alkohol* [see 234], are often prepared in the large way; but the several kinds of *Ether* [see 231, 232], are hardly made anywhere but in chemical laboratories, and apothecaries shops.

CXVII.

The preparation of *gunpowder* [see 236] is a subject the more particularly interesting, inasmuch as the art of war, as practised in modern times, in a great measure depends upon it. The three great objects here are to make it of the strongest quality, at the cheapest rate, and in the safest manner.

CXVIII.

To this head likewise belong the several contrivances for making the different sorts of combustibles that are made use of, either in war, or for pastime. This art is commonly called *Pyrotechny*, or the art of fire-working. The principal desideratum here, is the art of making a pure green fire, for which, however, chemistry affords several expedients.

CXIX.

As the colours of bodies depend on the reflection, transmission, and refraction of the rays of light; and as the changes, thus undergone by the light, seem to depend upon the phlogiston contained in the substances concerned; it follows, that the several contrivances for fixing colours on different bodies, naturally belong to the Theiurgic branch of chemistry.

CXX.

CXX.

Dying is the name given to the art, which, by impregnating a substance with a liquor prepared for the purpose, bestows on it the colour which is desired. The preparation, which the substance to be dyed is made to undergo, by means of certain salts, in order to make it take the colour the better, is called steeping.

CXXI.

This art is distinguished into several branches, according to the nature of the substances to be dyed; the principal of which are wool, silk, cotton, and linen. These substances differ very much with regard to the degree of facility with which they receive colours: wool, the easiest; after wool, silk; cotton and linen receive and retain them with the greatest difficulty.

CXXII.

CXXII.

Linen, in order to be rendered susceptible of certain colours, must receive an impregnation from some animal substance. As, by this means, it is brought nearer to the nature of wool, or other such animal productions, the process may be called *animalization*.

CXXIII.

The goodness of a colour depends not merely on its beauty and brilliancy, but also on its capacity of sustaining the influence of the sun and weather unaltered; to which may be added, in cloaths of a vegetable origin, their capacity of sustaining the action of soap in washing without change.

CXXIV.

By means of chemistry many discoveries have of late been made, as well in respect

to novelty of colour, as constancy of duration, and certainty of effect. A few examples will suffice: silk may now be made to receive the deepest scarlet; cotton the red Turkish colour, in different ways; linen a true black. In several cases, Prussian blue may now be substituted in the room of indigo; and even this dear colour may now, in several instances, be employed to better advantage than before.

CXXV.

Painting is an operation altogether different from dying: in the former case, a substance of some thickness is superinduced upon that which is to be coloured; in the latter, by means of a kind of attraction, the substance in question is covered with a merely superficial stratum of such particles as reflect the rays, which exhibit the colour we desire. That process, by which a thin colouring is given to wood, horn, leather, bones, &c. may be conceived as something between the former two. In this latter case,

case, sometimes the substance is only washed over with the colouring tincture, sometimes it is set to steep in it.

CXXVI.

The method of painting, in which the colours are employed dry, is called *Painting in crayons*: and this kind of work has also received improvements of late in point of durability. In the more common kinds of painting, the colouring materials are ground and mixed with oil, water, or spirit of wine, according to the purpose which is in view. In all these cases, it is only the production and attachment of the colouring matter that comes under the department of chemistry. The design and delineation of the figures belongs to a particular art, which ought not to be confounded with that which respects only the nature and preparation of the colours,

CXXVII.

CXXVII.

To this head also belong the different coloured *inks*; of which those kinds are called *sympathetic*, which remain invisible, until the colour is brought forth by heat, or by some other means. By means of these inks many pretty effects may be produced in drawings.

CXXVIII.

The black, and other colours which are used by printers and engravers, and are stamped on by plates, blocks, or types, require great nicety in the composition, in order to their being made to answer perfectly.

CXXIX.

To take away other colours is likewise an object in some cases, in order to obtain a perfect white: for this purpose, according to circumstances, different expedients are employed. Bleaching, for example,
upon

upon linen; and the fumes of sulphur upon silk and wool.

CXXX.

There is likewise a method of applying colours by fusion in the dry way. Examples of this are the different colours given to sealing-wax: formerly the blue was very much esteemed; but it is generally believed, that the art of making it is lost. The coloured glasses are made by melting common glass with the metallic calces; and they are at pleasure rendered transparent or opaque. By these means china may be made to receive colours, which afterwards must be burnt in.

CXXXI.

In this way also it is, in many cases, an object to discharge colours out of fusible substances, whether transparent or opaque. To obtain glass colourless, besides the ordinary materials, it is necessary sometimes to employ nitre, and frequently also manganese:

ganese: both of which strongly attract phlogiston. When nitre is employed, the acid, combining with the phlogiston which gave colour to the mass, flies off with it. The manganese, on the contrary, combining with a certain proportion of phlogiston, detains it, forming with it a compound which is colourless; though in any other proportions its particular colour always appears.

CXXXII.

To be able to preserve inflammable substances from conflagration, is doubtless an object of a most capital nature, on which, of late days, much study has been employed; and, as is shewn by the experiments which have been made, not without considerable success. The wood-work of houses may be made to resist fire a long while, by being covered over with clay. Wood and paper, well impregnated with a lixivium of pearl-ashes, will not catch fire. Alum and common sea-salt, &c. will

will produce the same effect. Another property of a solution of sea-salt is, that it does not easily freeze; on which account it may be employed with particular advantage in quenching fires, which happen in the cold season. A way of doing this is, by filling with the solution hollow balls or cylinders of thin iron, which, upon being thrown into the fire, burst with great violence, scattering the salt water all around.

CXXXIII.

Under the Metallurgic branch of chemistry are comprised the several processes, whereby the metals are extracted from their ores, purified and rendered applicable to a variety of purposes.

CXXXIV.

The business of determining the purity of metals, and other mineral substances, by experiments made in the small way, constitutes

constitutes a particular art, which is termed the *art of assaying*.

CXXXV.

Such experiments made on ores are of great importance, with a view to the corresponding works which are carried on in the large way; since by these means we are enabled to determine, at a very small expence, whether the latter are likely to be carried on to advantage.

CXXXVI.

To find out the cheapest, and best adapted process for smelting an ore, according to the nature of the mineral, and the circumstances of the place, is a chemical problem which surely is none of the easiest to resolve.

CXXXVII.

Most metals, after they have been extracted from their ores, must undergo a variety of other operations, before they

F can

can be rendered perfectly pure. Iron must be melted again and hammered; copper must be purified; silver and gold must be subjected to the test, refined from the baser metals, and separated from one another.

CXXXVIII.

Iron is very much improved by its conversion into steel.

CXXXIX.

In the business of compounding metals great care is required, partly in order to avoid waste in the operation, partly in order to produce a compound, which shall possess the properties required; partly also to prevent any loss, that might happen to the buyer or the seller, for want of a knowledge of their value.

CXL.

Copper combined with zinc produces, according to the different proportions employed,

ployed, brass, Pinchbeck, similor, and other mixtures; and, when combined with tin, makes bell-metal. With gold and silver a certain proportion of it is combined, in order to make them harder. Tin with lead forms pewter; with mercury, it forms the substance, which, being applied to the back of glass-plates, gives them the name of looking-glasses.

CXLI.

Assays are necessary for investigating the nature of all these several compositions; particularly of those in which gold, silver, or tin are ingredients: and for this purpose are instituted, in many countries, particular officers, under some such name as assay-officers, whose business it is to have a vigilant eye upon the goodness and genuineness of those articles.

CXLII.

Metals are brought into the form required, either by melting or by hammering.

In these operations, it is necessary to know how to manage the fire properly, in order to make sure, that in the first case the mass shall receive its proper degree of fluidity; in the second case, that it shall neither be calcined by the violence of the fire, nor break under the hammer.

CXLIII.

In some of the articles that are made in metal, either the surface is to receive a polish, or a coating of some other metal is to be given to it: thus, copper is covered with tin, silver is boiled white, brass is plated over with silver, and silver with gold. Gold, by being mixed with different alloys, is made to receive different colours, as is seen in many of the trinkets that are made of that metal.

CXLIV.

Various metals require also various *solders*, in order to join one piece to another; as also, various coatings, in order to preserve

serve them against the effects of the corrosive menstrum with which air and water are impregnated. To cover copper with something that shall render it more safe to use than it is rendered by the common method of covering it with tin ; to cover iron with some innoxious substance that shall preserve it from rust, &c. are problems of no small importance to mankind.

CXLV.

The opipeiary manufacturing branch of chemistry, treats of the lights that certain arts and manufactures which are carried on in the large way may need from chemistry ; although they do not, like those hitherto spoken of, depend altogether upon that science.

CXLVI.

To this head belong, in particular, the several processes for preparing furs, leather, hides, skins, and parchment ; all of which stand in need of different methods of treat-

ment, in order to render them fit for their respective uses.

CXLVII.

Furs are prepared with fat, and a solution of sea-salt. Those hides, of which the skin alone is made use of, are prepared with lime or acidulated waters, in order to take off the hair and fat; the hardness required is then produced by astringents, the softness by fat substances.

CXLVIII.

These processes, when conducted in the common manner, take up a considerable length of time; but this might undoubtedly be much shortened, since, by means of a proper knowledge of the subject, leather has actually been as well prepared in four weeks as it commonly is in four months.

CXLIX.

CXLIX.

In the woollen manufacture the wool must be properly cleansed; the *chain* properly glued; and the cloth properly fulled.

CL.

In the silk manufacture, the rawness must be taken off from the silk, which is entirely a chemical operation.

CLI.

In the linen manufacture, there occur likewise several operations which come under the department of chemistry. To this head may likewise, with propriety, be referred the preparation of the various sorts of paper.

CLII.

Different sorts of glue, size, and paste, are made use of for different purposes.

CLIII.

For the use of engravers, a kind of film or varnish is required, in order to secure the copper from being corroded every where, except in certain places. This varnish, or etching wax as it is called, should be made in such manner, as that it may be easily taken off when done with.

CLIV.

In the discharging of spots from the several sorts of cloths, it is necessary to know, in each case, not only what menstrua are adapted to dissolve and carry off the adventitious substance, but likewise how to chuse such as are innocent and will do no harm, either to the colour or the stuff.

CLV.

The most proper and cheapest covering for preserving wood from putrefaction, and for keeping off worms from that part of a ship
which

which is under water ; the easiest method of detecting adulteration in wines and other merchandise, &c. are objects of the greatest consequence to the public. Many more examples must be continually occurring to a man who pays any degree of attention to the subject, on which account we shall pass them over.

CLVI.

From all that has been said, it evidently appears, that, as well in private families as in various manufactories, a multitude of operations are continually occurring, which indubitably are of a chemical nature. They are not, it is true, at least not all of them, indebted to chemistry for their having arrived at that degree of perfection to which we see them now advanced. Some of these arts owe their first discovery to chance : these oftentimes remained a considerable time in an unimproved, and, as it were, in a barren state ; at last some man arose, who, by a happy combination of
courage

courage and ingenuity, struck out improvements, and endeavoured to turn them to account: and thus it has been that processes, which at first were altogether imperfect and ill-contrived, by dint of slow and successive efforts, aided by lights collected from accidental observation, have been brought to a state of perfection, far exceeding what could, in those early days, have been expected. But all this business has commonly gone on very slowly, partly because such people only have been concerned, who, destitute of all scientific acquisitions, had no choice left but to toil on in the track of blind experiment; partly because these employments being all they had to trust to for their support, they therefore naturally made a point of keeping their invention secret, which on that account frequently died with the inventors.

CLVII.

The obtaining of circumstantial accounts of the progress, but more particularly of the

the present state of the arts, cannot therefore fail to be looked upon as a great step towards their improvement. 'Tis from hence that chemistry might derive intelligence of many remarkable phenomena, which before were not known but in manufactories. She, on her part, far from being ungrateful, would be always ready to give in return a rich stock of useful hints and explanations, to all who would think it worth their while to consult her. It is evident that, setting aside those mechanical changes which are occupied only with the configuration of the surface, and therefore have nothing to do here, there can be no other ways of operating on bodies, but either by separating something from them, or compounding them anew: but it is according to the laws of elective attraction [see 30], that both separation and combination are performed; consequently it is from the knowledge of those laws, that the clearest lights and most effectual assistances are to be derived. A chemist, indeed, cannot create the original materials; yet, by
means

76 NATURAL BODIES

means of such methods as the science teaches him, he can put those materials into such circumstances, that, according to the different proportions and processes employed, they shall become combined in various manners; and by these means various bodies shall be produced, either similar to such as nature has prepared already, or even altogether new, and both sorts so modified, as to be adapted to the various uses to which we wish to apply them.

OF NATURAL BODIES IN GENERAL.

CLVIII.

Such is the variety of the bodies which compose the substance of this our globe, as cannot, upon a nearer inspection, but
excite

excite our admiration of the infinite power of the Creator.

CLIX.

Upon a general view, these bodies may be divided into two great classes ; one of them composed of such bodies as are made up of vessels and tubes, which carry up or give lodgment to the various juices destined to contribute to the growth and nourishment of their respective bodies. These bodies are called *organized*, and are again distinguished into such as possess sensation ; to wit, animals, and those which seem destitute of that faculty, to wit, vegetables.

CLX.

The other great class is composed of such bodies as are *unorganized*. These are composed of parts superficially cohering, which have no internal vessels or tubes for the conveyance of any nutritious juices, but grow no otherwise than by a simple juxtaposition. Of these the organic bodies are composed,

composed, and may accordingly be again resolved into them. The organic are the work of nature only; the unorganic may also be produced by art.

CLXI.

The unorganized bodies may be distinguished into six kinds: 1. salts; 2. earths; 3. inflammable substances; 4. metals; 5. water; 6. air. These two last might perhaps, not without reason, be ranked under one or other of the preceding classes; but, till we have obtained a more intimate knowledge of them, it may be as well to give them a separate consideration.

O F S A L T S.

CLXII.

The name of salt may be given to any body which excites a pungent taste on the tongue;

tongue, and combines with water so as not to require more than five hundred times its own weight of that menstruum, when boiling, to dissolve it.

CLXIII.

The taste and solubility are properties of which it is difficult to fix the limits: the former depends on the perfection of our organs; insomuch that what appears insipid to one man, appears sapid to another, and can therefore never be measured with any exactness.

CLXIV.

In regard to solubility, the degree in which this property is possessed by bodies, is difficult enough to determine; inasmuch as it depends partly upon the surface of the body to be dissolved, and partly upon the heat of the menstruum. It happens, in many instances, that a portion of the body in question, which will not dissolve when entire, may be made to dissolve only by being

ing reduced to powder ; and when the mechanical method of performing that operation proves ineffectual, the purpose may oftentimes be effected by a chemical one ; to wit, by first dissolving the body in a strong menstruum, and then separating it in the way of precipitation. The different degrees of solubility thus produced, depend, it is evident, on the magnitude of the surface ; as the greater this is, the more numerous are the points of contact between the solvend and the menstruum, and in that proportion consequently the force of the attraction is augmented.

CLXV.

Water is the more subtle and penetrating the warmer it is. Accordingly, a substance which does not dissolve in cold water, is oftentimes dissolved in warm ; and again, a substance which cannot be dissolved by simple boiling with water in open vessels, is oftentimes dissolved in close vessels, in which the water can be made to imbibe a greater degree of heat.

CLXVI.

CLXVI.

By the help of these considerations it should seem, that an artificial boundary might be set up, by which saline bodies might be distinguished from such as are not saline, with a tolerable degree of accuracy. Those may be deemed saline, which may be made to dissolve without being reduced to a powder finer than that to which they may be reduced by mechanical means only, and without any more boiling water than five hundred times their own weight, and that in open vessels (c).

CLXVII.

Salts may be distinguished into, first, the simple ones, to wit, those which che-

(c) The productions of nature are linked together, as it were, in an uninterrupted chain; in which, though we can evidently enough distinguish any two remote links from one another, it is but seldom we can distinguish any two that are contiguous.

G

mistry

mistry has not yet been able to decompose; and, secondly, compound, of which the analysis and synthesis are already known.

CLXVIII.

The simple ones are either acids or alkalis.

CLXIX.

Acid is the name given to those salts which are sour to the taste, which colour blue vegetable juices red, and effervesce with chalk.

CLXX.

These are further divided into the mineral acids, being such as are obtained chiefly from the mineral kingdom; the vegetable, being such as are obtained from the vegetable kingdom; the animal, being such as are obtained from the animal kingdom; and lastly, such as are obtained from all kingdoms alike.

CLXXI.

CLXXI.

The mineral acids already known are fix: the vitriolic; the nitrous, the marine, the acid of spar, the acid of arsenic, and that of borax (*d*). These, all of them, differ from one another in smell, specific gravity, and volatility; but most explicitly in respect to their different attractive powers, and the compounds they form with alkalis, earths, and metals.

CLXXII.

There are certainly a great variety of vegetable acids, though as yet we are acquainted with but few of them: these are the acids that are respectively found in sugar, in tartar, in sorrel, in lemon-juice, and in vinegar.

CLXXIII.

Of the animal acids that are known, the number is yet smaller: they are commonly

(*d*) To which may be added, the *Acidum Molybdene*, lately discovered by Mr. *Scheele*. Act. Stockh. 1778.

reckoned two; to wit, that which is found in ants, and that which is the characteristic ingredient in phosphorus. Yet this last is not only found in great quantities in the vegetable kingdom, but has likewise been found in certain mineral substances.

CLXXIV.

The aërial acid is found in all the three kingdoms in large quantities.

CLXXV.

Alkaline salts have a peculiar kind of taste, which, being like that of lixivium of wood-ashes, may be called lixivious. They change blue juices of vegetables into green, and combine readily with acids.

CLXXVI.

Of alkalis we know only of three sorts: two of them fixt, the other volatile.

CLXXVII.

CLXXVII.

The vegetable fixt alkali is obtained commonly from the ashes of trees, which have deciduous leaves; but the purest sort is obtained from burnt tartar (*e*).

CLXXVIII.

The mineral fixt alkali is found naturally by itself in several places. It may likewise be extracted from the ashes of marine plants, especially from the soda.

CLXXIX.

The volatile alkali is obtained the purest from sal ammoniac; less pure from animal and vegetable substances. It has an acrid taste and fetid smell.

(*e*) That which is called pot-ash has many heterogeneous substances mixed with it.

CLXXX.

The alkaline salts, upon being burnt, lose a portion of that quantity of aërial acid with which they are generally more or less combined. By quick lime, which has a stronger attraction for that subtle acid, they may be entirely freed from it; and then they are termed caustic. In this state they are acrid and corrosive, attract moisture strongly, produce heat, but do not effervesce with acids. The more aërial acid they contain, the milder they are, the easier to bring to a state of chrySTALLIZATION, and the more violently they effervesce when a stronger expels from them this weaker acid.

CLXXXI.

The compound salts are distinguishable into the neutral salts, and the sales medii or middle salts; the former do not yield any precipitate upon the addition of an alkali, the latter do.

CLXXXII.

CLXXXII.

Neutral is the epithet given to those salts which consist of an acid united with an alkali. In such combinations the former is frequently called the *menstruum*, the latter the *basis*.

CLXXXIII.

If the component salts are perfectly saturated with each other, they are called *perfectly neutral salts*; and of this kind are the greater part of those which, neither in respect of their taste, nor in respect of their action on other substances, resemble the simple salts. The case is the reverse with those that are stiled the *imperfectly neutral salts*, in which one of the elements predominates over the other.

CLXXXIV.

Of the perfectly neutral salts, the following are those which are most known: the

G 4

vitriolic

vitriolic acid, combined with the vegetable fixed alkali, gives what is called vitriolated tartar, more properly vitriolated vegetable alkali; with the mineral fixt alkali, Glauber's salt, more properly the vitriolated mineral alkali; with volatile alkali, Glauber's secret salt, more properly vitriolated volatile alkali. The nitrous acid, with the vegetable alkali, makes nitre, or nitrated vegetable alkali; with mineral alkali, cubic nitre, or nitrated mineral alkali; with volatile alkali, inflammable nitre, or nitrated volatile alkali. The marine acid, with vegetable alkali, gives the digestive salt of Sylvius, more properly salited vegetable alkali; with mineral alkali, the common or sea-salt; with volatile alkali, sal ammoniac, or salited volatile alkali. The acetous acid, or acid of vinegar, with vegetable alkali, constitutes the *terra foliata tartari*, or acetated vegetable alkali; with mineral alkali, acetated mineral alkali; with volatile alkali, *spiritus mindereri*, or acetated volatile alkali.

CLXXXV.

To the class of imperfectly neutral salts belongs tartar, which consists of vegetable alkali combined with a greater proportion of the acid of tartar than is necessary to saturate it. Upon saturating the acid with the alkali, there results a perfectly neutral salt, commonly called tartarized tartar, or soluble tartar; more properly tartarized vegetable alkali. The borax consists of mineral alkali, which is not perfectly saturated with the boracic acid.

CLXXXVI.

The compound neutral salts are besides distinguishable into such as are double, which are the most common; triple, which are composed of three elements at once, which is the case of the Rochelle salt, or salt of Seignette; quadruple, &c. &c.

CLXXXVII.

CLXXXVII.

Middle salts is the name given to those, of which one only of the elements is saline; the other not being by itself soluble in water, but being rendered so by its conjunction with that which is soluble.

CLXXXVIII.

If the basis is an earth [see 192], the compound may be called an earthy salt; if a metal, a metallic salt [see 239]. These last may almost all of them be distinguished by means of the phlogisticated alkali, which precipitates metals dissolved in acids, each with a peculiar colour.

CLXXXIX.

Each of these kinds are again distinguishable into double ones, triple ones, and so forth.

CXC,

The metallic salts exhibit yet another diversity which respects the nature of the menstruum: some metals being soluble by alkalis as well as by acids.

CXCI,

In our enquiries concerning the chemical nature of bodies, we ought to begin with salts; otherwise it is like building without a foundation. They are present in every part of the œconomy of nature; and there are few, perhaps not any of its operations, that can be carried on without them. Mean time the forms, under which they respectively manifest themselves, are in many cases very different. Some may by themselves be exhibited in a dry form, others cannot be brought to that state without being rendered almost immediately fluid again by the humidity of the air: these are termed deliquescent salts: others
are

are susceptible of crystallization: but of these again some lose in a dry air a part of the water they took up in crystallization, become opaque and crumble; some require but a little water to dissolve them, others a great deal, &c. &c.

O F E A R T H S.

CXCII.

Earth is the name given to those species of solid matter which remain unaltered in a red heat, without melting or flying off, notwithstanding they are reduced to the finest powder; and which are not soluble in open vessels in a quantity of water less than five hundred times their own weight.

CXCIII.

CXCIII.

The earths however are, in many instances, so far of a saline nature as to be soluble by means of Papin's Digester. This holds good even with regard to quartz. Indeed in the state in which they are found in the ground, they are always combined with an acid, and are therefore in fact, according to their different natures, so many sorts of earthy salts [see 188]. It would be proper, notwithstanding, for distinction sake, to arrange them under a different class from the one so intitled; and this we are enabled to do by means of the distinctions above laid down [see 192].

CXCIV.

Earths are distinguished into simple or primitive, and compound or derivative; the last being those which consist of two or more simple ones combined.

CXCV.

CXCIV.

Of simple earths there are not as yet known for certainty more than five: ponderous earth; calcareous earth, or lime; magnesia; argillaceous earth, or clay; and silicious, or crystalline earth: all which may easily be distinguished from one another by means of the phenomena they respectively exhibit, when combined with vitriolic acid.

CXCVI.

These five no one as yet has been able either to decompose, or to transmute one into another.

CXCVII.

The ponderous earth forms with vitriolic acid ponderous spar, which is not soluble in a thousand times its own weight of boiling water.

CXCVIII.

CXCVIII.

For any thing we know as yet, it is but seldom that this earth makes its appearance. There are many respects in which it resembles calcareous earth: for example, inasmuch as it unites with the aërial acid, effervescing thereupon with other acids; loses its aërial acid by exposure to fire, becoming thereupon soluble in water, but separating again from the water in open air, in the manner of the *cremor calcis*; and, when burnt, renders alkalis caustic, and combines with sulphur, &c.

CXCIX.

There are other respects, however, in which it shows itself quite different: with the nitrous and marine acids it forms salts, which are susceptible of crystallization, and which require a large proportion of water to dissolve them; at the same time that the compounds it forms with acetous acid are
6 deliquescent:

deliquescent: in both which particulars the phenomena exhibited by calcareous earth with the same acid, are entirely different. Another thing is, that the attraction which ponderous earth has for vitriolic acid is so strong, that it separates that acid even from the vegetable alkali; which is what never is done by calcareous earth: not to mention a variety of other circumstances.

CC.

Calcareous earth, combined with vitriolic acid to the point of saturation, forms *Gypsum*, which is soluble in five hundred times its own weight of boiling water. Gypsum is known by the property it has of forming, after a slight burning, a hard mass with water.

CCI.

Calcareous earth is found in great abundance, but commonly saturated with aerial acid, which exhibits the appearance of effervescence upon being driven from its
basis

basis by a stronger acid. Calcareous earth is found dissolved in most waters, by means of a redundant portion of the aërial acid. By burning it loses that acid, together with a proportion of water, which it was combined with, and enters into a chemical combination with a certain quantity of the matter of heat, in which state it is called quick lime; an article absolutely necessary in bricklayers work and masonry. Its having a greater attraction for water than for the matter of heat, is the reason, that when the quick lime meets with the former, it lets go the latter; by which means a great quantity of sensible heat is produced, converting a part of the water which it has absorbed into vapours; which, if the calcareous earth were in the form of a stone, would break it down into a fine powder.

CCII.

Magnesia saturated with vitriolic acid forms a bitter salt, known under the names

H

of

of English, Epsom, Seydschutz, or Seidlitz salt. Although the salts known under these different names differ from one another on account of some heterogeneous substance which is combined with them, yet the vitriolated magnesia is the characteristic and principal ingredient in them all.

CCIII.

Magnesia is seldom found alone, but there are several kinds of stones of which it commonly forms a constituent part. It is contained frequently in fresh waters, by means of a quantity of aërial acid which is dissolved in them; and in sea-water it is present in vast quantities, united with the marine acid. When saturated with aërial acid, it effervesces upon the application of a stronger acid. In the fire it parts easily with its aërial acid, but does not thereupon become soluble in water, as caustic calcareous earth does. It may be made to dissolve sulphur, but with difficulty, and that only in small quantities.

CCIV.

CCIV.

Pure argillaceous earth, dissolved with a scarce perceptible superabundance of vitriolic acid, forms alum.

CCV.

This earth is met with in vast quantities, but always mixed with a greater or less proportion of heterogeneous matters, especially with sand or silicious earth. The tenacity it possesses when mixed with a due proportion of those last-mentioned substances, and the property it has of becoming hard by burning, render it fit for being made into bricks and tiles, and several other implements.

CCVI.

The four kinds of earth above described might also be called *absorbent*, as they all absorb a quantity of aerial acid, exhibiting, upon the application of a stronger
H 2 acid,

acid, an effervescence, which however is much less conspicuous in the argillaceous earth than in any of the others.

CCVII.

The silicious earth is not affected by the vitriolic acid; it is, however, dissolved by that of spar.

CCVIII.

This is found every where in great quantities: in the rock crystal and transparent quartz it is perfectly pure. With alkalis it is brought into fusion in the dry way very readily; and, by its union therewith, constitutes that most useful manufacture which is called glass. That the acid of spar is a constituent part of the silicious earth there is no doubt; but the basis of it is not yet perfectly known. It seems however to be the fixt part of water; since by that acid and water together, the earth in question may be produced by art even in a crystalline form.

CCIX.

Of two or more of these five kinds of simple earths, all the others which have yet been examined, have been found to be compounded; the diamond excepted, which, in an open fire, evaporates entirely, or, to speak more properly, burns; since it goes off by degrees with a small flame, exhibiting likewise some signs of foot. This stone, which is of all known substances the hardest and most scarce, affords, at the same time, the most obstinate resistance to all menstruums whatsoever, and contains probably a peculiar kind of earth, which might be called noble earth, but the nature of which remains yet to be ascertained by diligent and exact experiments. Quite different is the nature of the ruby, the sapphire, the topaz, and the emerald: these are each of them compounded of argillaceous, filicious, and calcareous earth; of which the first is the most abundant, and the last present only in a very small quantity.

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tity. The different colours they possess, to wit the red, the blue, the yellow, and the green, are all derived from iron; which, for the different appearances it exhibits, stands indebted probably to its being differently modified by different proportions of phlogiston,

OF INFLAMMABLE SUBSTANCES.

CCX.

To this class belong all those bodies which are consumed by burning.

CCXI.

The foundation of this property of inflammability lies, properly, in a very subtle matter, which the ancients called phlogiston: so subtle indeed, that, were it not
for

for its combination with other substances, it would be imperceptible to our senses. It can, however, be made to migrate from one body into another, according to the laws of elective attraction; and it is by the changes it thereupon exhibits, and them only, that we learn so much as we are acquainted with of its nature. It is present probably, more or less of it, in all bodies; it renders, however, those alone inflammable, in which it exists in abundance, and with which, at the same time, it is not so strongly united, but that it may be driven out from them in great quantities under certain circumstances, by the rushing in of air.

CCXII.

Phlogiston, united with vitriolic acid to the point of saturation, forms what is commonly called sulphur.

CCXIII.

If sulphur be dissolved in an alkali, the compound is called liver of sulphur, or *hepar sulphuris*. This substance has the smell of rotten eggs, especially upon the application of an acid; in which case the sulphur is precipitated. It dissolves in water and spirit of wine.

CCXIV.

The solutions of sulphur in the several kinds of oils are called balsams of sulphur; they have a disagreeable smell, and in consistence they are thinner or thicker, according as the proportion of sulphur dissolved in them is less or greater.

CCXV.

Phosphorus also is a species of sulphur: but this consumes in a free air so slowly and gently, that letters written with it continue to give light in the dark for a long

long time together. It is composed of phlogiston and a peculiar kind of acid, which taking its name from the compound in question, is called *phosphoric acid*. This species of sulphur must be kept in water, as in the open air it very soon consumes.

CCXVI.

The other acids no one as yet has been able to combine with the phlogiston, in such manner as for them to form solid sulphur.

CCXVII.

Pyrophorus is the name given to a powder composed of alum and a little phlogiston, which begins to burn of itself, as soon as it is exposed to the open air. This phenomenon depends probably upon some hepatic principle, generated during the preparation of the powder.

CCXVIII.

CCXVIII.

The Bolognian Phosphorus is a name given to the ponderous spar, or *spathum ponderosum* [see 197], which has been ignited upon live coals, and has thereby received the power of attracting a quantity of light, which it emits afterwards in the dark.

CCXIX.

Baldwin's Phosphorus possesses the same property, but is prepared from chalk dissolved in nitrous acid; which compound is evaporated to dryness, and then made to undergo a certain degree of ignition.

CCXX.

The sparry fluor, or *fluor spathosus*, also yields, when heated by degrees, a fine phosphoric light, which is likewise yielded by several other substances, although in a weaker degree. Sugar, the ore called *pseudogalena*,

dogalena, &c. give light in the dark upon being rubbed.

CCXXI.

Oil is the name given to certain greasy liquids, which do not mix with water, which are susceptible of combustion; yield a great deal of flame and smoke in burning, and leave a coal behind them when they are burnt out.

CCXXII.

The elements they are composed of are phlogiston, ærial acid, and water.

CCXXIII.

They are distinguished into two kinds, the unguinous and the essential.

CCXXIV.

Unguinous is the name given to those which are without smell and taste, are not
soluble

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soluble in spirit of wine, nor volatile in the heat of boiling water.

CCXXV.

If these oils are forced over in distillation by a stronger heat, they acquire a burnt smell and taste, and become soluble in spirit of wine: in this state they are called empyreumatic, and sometimes philosophical oils.

CXXVI.

Tallow, butter, and other animal fats, are similar to unguinous oils in most respects.

CCXXVII.

Essential oils have a strong taste and smell, of which the latter is commonly most agreeable. They are soluble in spirit of wine, and volatile in the heat of boiling water.

CCXXVIII.

CCXXVIII.

The principle to which they owe their smell, is a very subtle oleaginous fluid. This is called their *spiritus rector*; it flies off in time, and in proportion as this happens, the oils lose their smell, and become viscid and heavier than they were before.

CCXXIX.

Dippel's animal oil must not be confounded with the common animal oils mentioned in § 226: it is obtained by distillation from the gelatinous substance of animals. It is at first of a deep brown colour, tenacious consistence, and empyreumatic smell: but it may, by repeated rectifications, be brought to such a degree of limpidity as to resemble ether [see 231]: but if the air is suffered to have access to it, it grows brown again.

CCXXX.

CCXXX.

The oils break out into a flame upon the application of nitrous acid: a pleasing and singular appearance, to be produced by the mixture of two cold fluids.

CCXXXI.

Ether is the name given to a subtle oil, which combines with ten times its weight of water, has an agreeable refreshing smell, and burns strongly, giving some signs of foot, but not leaving any coal behind. Its volatility is so great, as to turn water into ice in a warm room: for all evaporation produces cold, in proportion to the celerity with which it is carried on. Ether takes gold from the solution of it in aqua regia, and has the property also of dissolving the elastic resin.

CCXXXII.

CCXXXII.

Hoffman's anodyne liquor is a solution of ether in spirit of wine.

CCXXXIII.

Spirit of wine is a fluid inflammable substance, which combines with water in every proportion, burns without foot, and without leaving a coal behind it.

CCXXXIV.

It consists of phlogiston and water, which are probably united together by the intervention of an acid; when deprived as much as possible of all superfluous water, it is called alcohol.

CCXXXV.

Of bodies which deflagrate with great violence and noise, there are several preparations: the three following are the most remarkable.

CCXXXVI.

CCXXXVI.

Gunpowder is a composition made of nitre, sulphur, and charcoal in certain proportions: that of the first being the largest, and commonly three-fourths of the whole. The charcoal and sulphur are no otherwise necessary, than to make it burn so much the quicker; and it is the nitre only, properly speaking, that makes the explosion. This salt burns with great violence, whenever it touches an inflammable body in a state of ignition.

CCXXXVII.

Pulvis fulminans, or thundering powder, is a mixture of three parts of nitre, two of the alkali of tartar, and one of flowers of sulphur. It explodes with a violent report when melted in an iron spoon over the fire. It seems as if this effect depended on the detonation of the *hepar sulphuris* generated during the fusion: for nitre with
half

half its weight of hepar sulphuris makes the same report.

CCXXXVIII.

Aurum fulminans consists of gold which has been dissolved in *aqua regia*, and precipitated by volatile alkali. This precipitate, whenedulcorated, dried, and then heated to a certain degree of heat, gives a prodigious report. It may even be prepared in such manner as to explode, by being only shaken about a little in a piece of paper.

O F M E T A L S.

CCXXXIX.

Metals are shining opaque bodies, which are heavier than all others : the lightest of them being six times the weight of water,
I and

and some of them almost twenty times its weight.

CCXL.

The metals with which we are at present acquainted, are fifteen in number, viz. gold, the specific gravity of which is to that of water as $19\frac{1}{2}$ to 1; platina as 18; quicksilver as 14; lead as $11\frac{4}{10}$; silver as 11; vismuth as $9\frac{8}{10}$; copper as $8\frac{8}{10}$ nickel; as $8\frac{5}{10}$; arsenic as $8\frac{1}{10}$; iron as 8; cobalt as $7\frac{7}{10}$; tin as $7\frac{7}{10}$; antimony as $6\frac{7}{10}$; and manganese, the specific gravity of which has not as yet been exactly discovered (*f*).

CCXLI.

Metals are compounds formed of phlogiston and so many different kinds of earths, which are termed the calces of the respective metals, and have no similitude with any of the earths above described [see 192 to 209].

(*f*) According to the latest discoveries of Mr. *Bergman*, about as $6\frac{8}{10}$.

CCXLII.

Those metals, in which the phlogiston and the calx have so strong an attraction for one another as not to be separated in an open fire, are called the *noble metals*. In the humid way indeed they may be calcined; but when a certain degree of fire is applied, they are thereby alone, without any addition being necessary, made to reassume their metallic form.

CCXLIII.

To this division belong *gold, platina, and silver.*

CCXLIV.

The *base* or *ignoble metals*, on the other hand, are those which lose in an open fire their metallic form, and are changed thereupon into a powder, resembling an earth; which powder resumes not in the fire its metallic form, without the application of an inflammable body.

CCXLV.

To this division then belong the remaining metals, quicksilver excepted, which is, as it were, of a middle nature between that of the noble and the ignoble metals: since, on the one hand, it may by fire, like the latter, be calcined; but, on the other hand, like the former, it may, without any addition, be reduced again to its metallic form.

CCXLVI.

Some of the metals are malleable, and to these alone, strictly speaking, does the name of metal properly belong. Gold is capable of being extended to a surprising degree: inasmuch that 651,590 cubic inches, may be covered with a cubic inch of it. Lead is the least malleable. Platina, silver, copper and iron, come between.

CCXLVII.

CCXLVII.

Quicksilver is as much a metal as any of them: for when reduced to solidity by a certain degree of cold, it is malleable nearly in the same degree as lead.

CCXLVIII.

Semi-metal is the name given to all metallic substances, which break under the hammer. Zinc is the most malleable of them all; nor will it suffer itself to be reduced to a powder so readily as the others; to wit, vismuth, nickel, arsenic, cobalt, antimony, and manganese.

CCXLIX.

Vismuth, antimony, and arsenic, upon being broken, appear to be of a foliated texture: the rest appears to be more or less finely granulated.

CCL.

The colour of them is of various hues : gold is yellow ; copper of a reddish yellow ; nickel and vismuth bear a little towards a whitish red ; platina, silver, quicksilver, tin, and antimony are white ; lead, zinc, iron, cobalt, arsenic, and manganese, verge towards the blue or green.

CCLI.

The metals require a very different degree of heat to melt them : quicksilver so little, that the atmosphere is scarce ever without a quantity sufficient for that purpose ; the rest stand in point of fusibility in the following order : tin, vismuth, lead, zinc, arsenic, antimony, silver, gold, cobalt, nickel, copper, iron, manganese, and platina ; which last, without previous preparation, can no otherwise be brought into fusion but by a burning mirror.

CCLII.

CCLII.

It is remarkable, that some metallic compositions become more fusible than any of their component metals: lead, tin, and vismuth, combined in a certain proportion, are fusible in the heat of boiling water.

CCLIII.

Six metallic substances are volatilisable by fire: quicksilver, arsenic, zinc, antimony, lead and copper.

CCLIV.

Zinc and arsenic are inflammable: the former burns with a beautiful green flame. Copper and gold exhibit also during their fusion a greenish lustre.

CCLV.

All metallic substances are capable by themselves of being united with sulphur,
I 4
gold

gold and zinc excepted; which cannot be united with it but by the intervention of some third substance, which has a common attraction for both the elements that are to be combined.

CCLVI.

A metallic substance is said to be mineralized, when, by being combined with sulphur, it has lost its metallic form.

CCLVII.

The metallic calces are capable of being vitrified, and in that state give the different colours which are used in enamel.

CCLVIII.

White arsenic is the calx of the semi-metal so called, which dissolves in water. It may also be entirely freed from its phlogiston, and is then found to be a particular kind of acid. This gives us occasion to suspect, that the other metallic calces
are

are all of them but so many particular kinds of acids, which continue to retain the quantity of phlogiston, which is necessary to inspissate them, and enable them to retain their solid form. By reflection and perseverance we may one day, perhaps, find means to overcome that attraction, which prevents us, as yet, from setting free the acids of the other metallic calces.

CCLIX.

When the metallic calces are made to lose a great portion of their phlogiston, they are either not soluble at all by acids, or at least not without great difficulty. As little can a metallic substance be dissolved, so as to retain its whole quantity of phlogiston. In order for a solution to take place, it is necessary that the metal should possess a certain quantity; more or less than which would equally prevent the effect. A most eminent instance of this, is that of manganese; which, when it is in its metallic form, must always part with a
quantity

quantity of its phlogiston before it is capable of being dissolved; but, when it is in the form of a white calx, is dissolved without any such loss; and at last, when calcined to blackness, is not attacked by acids at all, unless a quantity of phlogiston be restored to it.

CCLX.

The science which furnishes us with distinct and certain characters, by which the several sorts of salts, earths, inflammable bodies, and metallic substances, may be distinguished from one another, has received the name of *mineralogy*.

O F W A T E R,

CCLXI.

Water is a substance that exists every where: we find, accordingly, that nearly
the

the half of the surface of our globe is covered with it.

CCLXII.

We can hardly frame to ourselves any other general idea of a fluid body, than that it consists of a quantity of infinitely fine and solid particles, which, by reason of their fineness, and the weakness of their attraction of cohesion, are so easily moved one over another, that the whole assemblage of them tends constantly to maintain a horizontal surface. Something of this sort is seen even in sand; which, in some places, is so fine, that a man may, as it were, be drowned in it. If then the interstices of such a fluid be filled up by one still finer, the particles acquire still a greater degree of mobility; and this is precisely the case with water.

CCLXIII.

Heat is that fluid which augments the fluidity, not only of water, but also of
all

all other substances : and according to the quantity of it which water possesses, it appears to us in three different forms.

CCLXIV.

If the quantity of the heat in water is so small, as not to raise the mercury in *Celsius's* thermometer above the degree which is marked O, the particles of the water lose their faculty of sliding over each other, adhere together, and form a solid, clear, and elastic mass, which is lighter than the water was before, and which is known to us under the name of ice.

CCLXV.

That the particles upon this occasion endeavour to crystallize, or range themselves into a certain order, is evident ; and this is one capital reason why the mass expands itself, and occupies a larger space.

CCLXVI.

CCLXVI.

When ice thaws, it is found to contain as much sensible heat as is indicated by *Celsius's* thermometer, when the mercury stands at 72 [see 297]. This quantity of heat is the least which is necessary to restore the substance to a fluid state; and any farther addition augments its fluidity in proportion to the quantity that is added.

CCLXVII.

Water in its fluid state is susceptible of compression, though but in a small degree.

CCLXVIII.

But when the aqueous particles receive a superabundant portion of sensible heat, over and above what is necessary to bring them to a liquid state, they are converted into elastic vapours; which change takes place in a most remarkable degree, when the mass is at the heat of boiling water. In
that

that degree of heat, a given quantity of water does so far expand itself, as to occupy fourteen thousand times the space that it did before, and thereby obtains a proportionably greater number of points of contact with the matter of heat; which thence is capable of being united with it in a larger proportion. And this seems to be the way in which that degree of cold is produced, which may be observed constantly to take place upon evaporation. This union however is again destroyed upon refrigeration.

CCLXIX.

As in all degrees of heat above O vapours are generated continually, it follows, that the particles, in order to assume an elastic form, stand not in need of any very considerable quantity of heat; but only the less heat they have, the less they are elastic.

CCLXX.

CCLXX.

If it be asked which of all these forms [see 264 to 269] are most natural to water? the answer is, that they are all natural to it alike. But if the question be, in which of them the water is freest from all heterogeneous particles? the answer is plainly, in that of ice.

CCLXXI.

Whether the primary elemental particles of water are homogeneous with respect to each other, or heterogenous, is difficult to ascertain: yet the latter opinion does not seem to be inconsistent with the plan pursued by nature with respect to other substances.

CCLXXII.

That these particles, in the common course of nature, can be so modified as to be made to lose their ordinary state with respect

respect to attraction, so as to exhibit themselves in the form of an earth, seems also to be not incredible; but that the experiments which have as yet been cited in support of this proposition, do not prove any such thing, is evident enough.

CCLXXIII.

The dissolvent power of water is one reason why it is always found more or less loaded with heterogeneous particles; of which some, by reason of their fineness, hang suspended in it, while others perhaps, are, properly speaking, dissolved in it.

CCLXXIV.

In the mechanical way may be mixt with it any sort of solid substances whatever, when reduced to a certain degree of fineness; and these may also remain suspended in it, when the friction which they would have to overcome, before they could fall to the bottom, becomes greater than the
overplus

overplus of their specific gravity with respect to water.

CCLXXV.

The substances which water is capable of containing in a state of solution, may be distinguished, in a general point of view, into such as are volatile and such as are fixt.

CCLXXVI.

Of the former of these classes are ; first, pure air [see 283] ; secondly, aërial acid [see 337] ; and thirdly, hepatic air [see 308].

CCLXXVII.

Of the latter or fixed kind there are various soluble substances : these, however, are seldom of the simple kind, but commonly either the neutral or middle salts : for example, vitriolated vegetable alkali, or more commonly, vitriolated mineral alkali. In the same manner are found the several

K compounds

compounds of vitriolic acid with calcareous earth, with magnesia, and sometimes with clay, iron, copper, and zinc. Those of nitrous acid with vegetable alkali; seldom those of the same acid with mineral alkali; sometimes those with calcareous earth and magnesia; seldom those of marine acid with vegetable alkali; often those of the same acid with mineral alkali, calcareous earth, and magnesia; those of the aërial acid with mineral alkali, calcareous earth, magnesia, and iron.

O F A I R.

CCLXXVIII.

The invifible fluid which every where furrounds our globe, is commonly called the air, or, more properly, the atmosphere;
as

as it is a mixture of a variety of substances, which agree; indeed, inasmuch as they are all of them of a subtle, elastic, transparent, and fluid nature, and in point of specific gravity near eight hundred times lighter than water; but which, in a variety of other respects, are found to be very different.

CCLXXIX.

Of late days we have began to comprehend, under the name of airs, all sorts of substances, which, being of a transparent, elastic, homogeneous, subtle, light, and fluid nature, retain their aërial form in the greatest cold to which they are known to have been exposed. When the nature of these comes to be thoroughly known, there can be little doubt but that they may all of them be brought under one or another of the before-mentioned divisions [see 161]; which already is the case with great part of them [see from 308 to 342]. In the mean time, there will be a convenience in

continuing them under their present name, since thereby we have the advantage of placing them altogether under one point of view.

CCLXXX.

Vapours is the name that may be given to all those elastic fluids, which lose by cold their aërial form, and re-assume again that which belonged to them before the heat, which they had imbibed, had endued them with that extraordinary degree of subtlety and elasticity. The vapours of water are condensed during the course of their refrigeration into drops, which consist of water, as before. The same thing happens with regard to the vapours of other substances.

CCLXXXI.

There are a great variety of different sorts of vapours. All bodies liquid in the heat of the atmosphere, may be brought into such a state; as also all solid bodies,

if

if not with respect to the whole of their mass, at least with respect to certain parts of it. According to the nature of the soil, the climate, the situation, and a variety of other circumstances, the atmosphere must therefore become a kind of place of rendezvous for a multitude of different vapours; which not only give occasion to thaw, rain, hail, and snow, but also, according to their different qualities and mixtures, to the several sorts of lights, explosions, and coruscations, which are wont to be comprehended under the general name of meteors.

CCLXXXII.

Setting aside vapours, which are continually varying, as well in point of quality as quantity, the atmosphere (as far as we have reason to believe), contains every where, and at all times, three different kinds of ærial fluids; viz. pure or aphlogistic air, phlogisticated air, and ærial acid; and the mixture, composed of all

these three, may go under the name of common air.

CCLXXXIII.

At the surface of the earth, the pure air constitutes not more than $\frac{1}{4}$, or, at most, not more than a third, of the bulk of a given quantity of common air; at the same time, the proportionable quantity of this pure air is undoubtedly a matter of the highest importance to every thing that breathes.

CCLXXXIV.

It is this air only that is fit for animals to breathe; and which is so necessary to fire, that, without it, the inflammation ceases in a moment.

CCLXXXV.

In respect to these properties, it has nearly eight times the power of common air [see 226 to 228].

CCLXXXVI.

CCLXXXVI.

The nature of it, as to what concerns its origination, is not yet determined. The strong propensity it has to attract phlogiston, affords some reason for supposing it to be acidulous ; but it makes no change at all in the colour of the tincture of lacmus [*gummi laccæ*]. Notwithstanding this, it contains aërial acid ; which may be precipitated from it, as well by electricity, as by other processes which have the effect of impregnating it with phlogiston. Hence it should seem, that aërial acid forms exactly one constituent part of it ; and the rest must consequently be something which has the property of laying hold of an acid, and entering into an intimate union with it, but yet has a still stronger attraction for phlogiston.

CCLXXXVII.

Besides that portion of the aërial acid which enters into the internal composition

K 4

of

of pure air, there is also always found in the common air a small portion, which is free and uncombined; but which seldom, however, constitutes more than $\frac{1}{15}$ part of the whole bulk of common air.

CCLXXXVIII.

This loose portion of aërial acid is easily separated from the rest of the air, by only making it pass through a lixivium of caustic alkali, or lime-water. It is also, by means of this acid, that such lixivia, upon being exposed to the open air, gradually become milder and milder, till at length they crystallize; and that lime-water also comes to throw up the pellicle [*cremor calcis*] on its surface.

CCLXXXIX.

The aërial acid is altogether unfit for respiration, insomuch that it kills animals instantaneously, putting an end, at the same time, to all irritability, even to that of the heart. In an instant it also extinguishes

guishes fire. Water absorbs it to such a degree, as to take up a bulk of it equal to its own, and is thereby rendered acidulous.

CCXC.

The third and remaining portion of the common air, which is still greater than both the two former put together, is altogether unfit, as well for respiration as combustion; and is moreover not absorbed by water.

CCXCI.

The true nature and composition of this part of the air is not yet determined; but since the pure air is entirely spoilt and rendered unfit, as well for further respiration as for combustion, by having been breathed, by having been made subservient to the destruction of inflammable substances by fire; as also by having received the effluvia of bodies in the state of putrefaction, and by other processes, in which a great quantity of phlogiston is disengaged, there is great reason to look upon it as phlogisticated,

cated. If this is really the case, those who inhabited the globe immediately after its creation, must, it should seem, have breathed a much purer air than we do now, when animals, fires, and putrefactions, &c. have, for so many thousand years, been contributing to its depravation. Might not this, perhaps, be the cause of the longevity of the first inhabitants of our globe?

CCXCII.

But if it be true, that the quantity of pure air is thus undergoing a continual diminution, it should seem, at first sight, that at length it must be so far reduced, that all animals must be suffocated, and all fires extinguished. Nature, however, has probably made some sort of provision for restoring and purifying depraved air, at least in part. It has been supposed, that this might be effected by agitation with water, and that such a process is actually carried on in the large way, by the continual motion of the sea; and further, that

5 vegetables,

vegetables, in growing, separate and absorb the depraving matter. This important question will, it is to be hoped, be decided by further and more accurate experiments.

CCXCIII.

Although pure air, combined with a certain quantity of phlogiston, seems to constitute the same sort of noxious substance which depraved air is; we have, notwithstanding, reason to believe, that the matter of heat (that substance which is so indispensibly necessary to all living creatures) is no otherwise produced than by the union of pure air with a certain different proportion of phlogiston. That the same elements, combined in different manners, or in different proportions, may produce different bodies, is already pretty well proved in various instances.

CCXCIV.

It is also, at this time, by a multitude of experiments, put out of doubt, that heat
consists

consists merely in an internal motion taking place among the particles of the several sorts of substances that are susceptible of it. It is, on the contrary, a substance *sui generis*, a particular subtle kind of fluid, which penetrates or pervades all, even the densest bodies, and thereby, according to its quantity, produces those particular sensations in animals, which are called cold, warmth, and heat.

CCXCV.

Fire is therefore neither more nor less than that state of inflammable bodies, in which the greater part of the phlogiston, which enters into their composition, is torn away by means of the pure air, with great force and violence from those particles with which it was before combined. This, then, is the way in which a great quantity of heat, or what comes to the same thing, what we call fire, must necessarily be produced [see 293]. As to the flame, it is, properly speaking, generated
from

from inflammable air [see 298]; which, in these circumstances, is detached from all inflammable bodies in great quantity, and very readily takes fire.

CCXCVI.

As to the light, which in these circumstances is also always generated, it appears probable, from a variety of experiments and observations, that this substance is composed of heat, charged with a certain over-proportion of phlogiston. He who considers in what different forms water shows itself when in a liquid state, and when in a state of vapours, and that owing to no other cause than the different quantities of heat which it contains, will hardly pronounce it absolutely incredible, that a different proportion of phlogiston should convert heat into light; although he should not yet have been informed of the reasons by which that proposition is made out.

CCXCVII.

CCXCVII.

Heat, then, being a substance, is, like other substances, subject to the laws of attraction. Accordingly, when it is present in bodies in such a manner as to form a constituent part of them, that is, to be in a state of chemical combination with the other elements of which they are composed, the power which it has, in other circumstances, of exciting the sensation of warmth, is found to be compleatly masked, as it were, and suspended, in the same manner as the characteristic properties of an acid are by combination with an alkali. Hence it comes, that, upon the decomposition of such bodies, a sensible heat or warmth is produced: the matter of heat, which before was fixt, being now disengaged or set at liberty, by a more powerful attraction.

CCXCVIII.

Inflammable air is the name given to that sort of air, which, upon the application

tion of a body in a flaming state, takes fire immediately, exhibiting also the appearance of a flame. When a bottle is filled perfectly full of pure inflammable air, the air must be set on fire, and deflagrated several times, before it is entirely consumed.

CCXCIX.

It may be set on fire not only by a flame, which never fails, but also by a burning coal, by a red-hot iron, by sparks of the electrical kind, and by such as are produced by the collision of a flint with a piece of steel. Hence it is, that small pistols have been loaded with inflammable air, and then fired by electricity; in which case the spark need not be stronger, than what is sufficient to set on fire spirit of wine.

CCC.

If common air be mixed with inflammable, it makes a report in burning, and the whole goes off at once.

CCCI.

CCCI.

Inflammable air mixed with nitrous [see 321], deflagrates with a green flame; but with aërial acid it will not mix at all.

CCCII.

An electrical spark, passing through inflammable air, appears of a purplish red.

CCCIII.

Inflammable air is obtained from all the three kingdoms of nature, often without any other process than the application of a strong fire: each different kingdom, however, gives a different smell to the air which is derived from it. It is also obtained from certain metals, by solution in the vitriolic and marine acids. It turns silver black.

CCCIV.

CCCIV.

The sort of inflammable air which is afforded by organized bodies, is distinguished, by certain circumstances, from that which is obtained from such as are not organic. That which is obtained from mineral bodies, requires, in order to produce the strongest report, an admixture of no more than $\frac{2}{3}$ of its bulk of common air; and of pure air, only one half: in which last case, the report is from forty to fifty times as loud again as in the former; whereas that which is produced from organic bodies, requires an addition from ten to twelve times its bulk of common air, in order to deflagrate at once. With regard to the flame, this in the former kind of inflammable air is of a red cast, in the latter of a blue.

CCCV.

In marshes, ponds, and rivers, where the soil underneath contains substances in a
L state

state of putrefaction, such an air, upon stirring the ground under the water, will often rise in such a quantity, as to take fire on the surface of the water, upon the application of any burning body. It seems to be this air, that, when mixed with the rest of the atmosphere, and set on fire by the electricity of the clouds, occasions the phenomena, which are called Will o' the wisps, and falling stars.

CCCVI.

Vegetables grow in this air, but the inflammability of it is not thereby increased. Animals die in it; and a lighted candle, when plunged below the surface of it, goes out.

CCCVII.

The nature and constitution of it is not yet found out. That phlogiston is contained in it, there can hardly be any doubt. That it also contains the matter of heat, appears from the sensible heat detached
5 from

from it when deflagrated. But since inflammable air cannot penetrate through glafs, as heat and light do, there muft be fome other element contained in it; unlefs it be fupposed, that the difference in queftion may have been produced by fome difference in point of proportion, and mode of combination. By a long continued agitation in water, we are told, that it may be rendered fit for refpiration.

CCCVIII.

The compofition of the *hepatic air*, is a little better known to us: it confifts of fulphur, which, by the help of phlogifton, is united with the matter of heat. And, that thefe are its real conftituent elements, may be demonftrated, as well in the fynthetic way, as in the analytic. It is remarkable, that fulphur is, in this cafe, refined into an elastic invifible fluid. It turns filver black.

CCCIX.

This sort of air is obtained not only from hepar sulphuris, by applying to it an acid, but also from sulphur, when melted with iron filings, and from all *galenas*. Nature also generates it in many places in considerable quantities: for it is found in several mineral waters, such as those at Aix-la-Chapelle, &c.

CCCX.

The marine acid, owing to the small attraction it has for phlogiston, is the fittest to produce this air; on the other hand, nitrous acid, is, for the opposite reason, the unfittest: since it attracts the phlogiston so strongly, as not to let any of it escape, so as to serve for uniting the sulphur with the matter of heat; it even destroys that union when already formed, and thereby affords a means of separating the sulphur from hepatic waters.

CCCXI.

CCCXI.

Distilled water absorbs a little more than half its bulk of hepatic air, and thereby contracts the same disagreeable taste and smell, as that elastic fluid itself possesses.

CCCXII.

This air extinguishes a burning candle when plunged into it; but, when $\frac{2}{3}$ of its bulk of common air is added to it, the mixture may be set on fire: in which case a sulphureous powder precipitates from it, and a smell of phlogisticated vitriolic acid may be perceived.

CCCXIII.

Means have also been found to bring several of the simple salts into the form of air: to wit, the vitriolic, the nitrous, the marine, that of spar, and the acetous acids, as also the volatile alkali; and to each of these we shall give a separate consideration.

CCCXIV.

The vitriolic acid may, even when pure, be brought by heat into the form of vapours ; but these, upon cooling, lose their elasticity again, and run into a fluid as before. By this means, therefore, nothing is gained ; upon adding, however, any substance which contains phlogiston, the business is done very easily. The air thus obtained is called the *acid vitriolic air*.

CCCXV.

This elastic fluid must not be made to pass through water : for if it be, it unites with it immediately, forming with it a phlogistified vitriolic acid : but if collected in vessels filled with quicksilver, it retains its form, even in the greatest degree of cold.

CCCXVI.

This fluid has a strong attraction to water, and thence also ice dissolves in it in a moment ;

moment ; and in the same manner it also converts camphire into a fluid oil.

CCCXVII.

When an electric spark is transmitted through this air, the inside of the glass becomes covered every where with a black stain ; which is the thicker, the oftener the experiment is repeated.

CCCXVIII.

Candles are extinguished, and animals die in it.

CCCXIX.

This vitriolic air is nothing more than vitriolic acid, which is deprived of its redundant water, and is united, not only with phlogiston, but with the matter of heat. Means, however, have not yet been found of charging it with phlogiston in such a manner, as to mask its acid properties altogether. These properties, however,

are remarkably weak, and it accordingly gives place as well to the nitrous acid, as to the marine.

CCCXX.

The nitrous acid is remarkably greedy of phlogiston, and accordingly forms with it, to the different proportions in which the two ingredients may be united, various compounds: among which we shall, in this place, speak of those only, which appear in the form of an elastic fluid, continuing such in the cold.

CCCXXI.

When nitrous acid is applied to a body which contains phlogiston, there arises from it, often without the help of the least external heat, an elastic fluid, which may also be collected in water as well as quicksilver, and which is commonly called *Nitrous air*.

CCCXXII.

CCCXXII.

Water abforbs a certain proportion of it, and alfo by degrees decomposes a part of it, when they are kept ftanding in contact with one another for a confiderable length of time.

CCCXXIII.

The acid which enters into the compofition of nitrous air is, in that cafe, fo perfectly faturated with phlogifton, that it cannot fo much as give a colour to lacmus.

CCCXXIV.

Animals as well as vegetables, die in this air. A candle alfo is extinguifhed in it: but, when it contains a redundant proportion of phlogifton, over and above what is neceffary for the faturaton of the acid, the flame grows much larger, and becomes a little greenifh, before the candle goes out. This superfaturation may be produced,

produced, either by letting the air stand upon iron-filings, or by taking the electric spark in it.

CCCXXV.

This air resists putrefaction, and that in a much greater degree than the aërial acid does.

CCCXXVI.

But the most remarkable circumstance belonging to this air, is the appearance it exhibits with pure air [see 283]: the attraction of which for phlogiston is so powerful, that it takes it away, in this case, even from nitrous air; which then becomes common nitrous acid as before. During the commixture of these two airs, a quantity of sensible heat is let loose throughout the whole mass, a reddish brown colour is produced, and the sum of the spaces occupied by both becomes much smaller than it was before. A given measure of pure air can even absorb three times its own bulk

bulk of nitrous air, before the space it occupies can be seen to be much augmented.

CCCXXVII.

Common air, as it contains a portion of pure air, and by that means alone is enabled to support combustion and respiration, exhibits accordingly, with nitrous air, a similar appearance, although in a less degree [see 326]. Indeed, common air cannot, in general, absorb more than half its bulk, without evidently occupying a larger space than it did before.

CCCXXVIII.

In none of the kinds of air which are unfit for respiration, is either the red colour, or the diminution of space, exhibited: consequently, the nitrous air affords us an excellent means of judging of the purity of the [atmospheric] air. It is always the purer, the greater the change is which it exhibits, upon being mixed with nitrous air: and on this circumstance is grounded

grounded the invention of the several sorts of *Eudiometers* [see 51].

CCCXXIX.

When concentrated vitriolic acid is applied to common salt, a kind of air is detached, which, if collected by means of quicksilver, remains unaltered; but which is instantly absorbed by water, to which it attaches itself in the form of common marine acid. This air is commonly called *Marine acid air*, and the marks it gives of its acidity are very evident.

CCCXXX.

Like the vitriolic acid, it dissolves ice and camphire; flame is extinguished by it, appearing blue at the instant of its evanescence.

CCCXXXI.

Electrical shocks transmitted through it diminish the bulk of it a little; but notwithstanding

withstanding this, the greatest part of it is afterwards absorbed by water.

CCCXXXII.

As neither the pure vitriolic acid nor the nitrous can be brought into the form of a permanent air, without the addition of phlogiston, at the same time that the case is otherwise with the marine acid; this circumstance inclines one to suppose, that phlogiston may be an essential constituent part of it: a fact which is also indicated by other observations.

CCCXXXIII.

The marine acid may be deprived of its phlogiston, as well by nitrous acid as by manganese. It shows itself in this state in the form of a reddish brown air, without any acidity, and without any particular inclination to unite with water, &c. In this state it is called dephlogisticated marine acid. By the re-addition of phlogiston,

giston, it may be made to reassume all the properties of common marine acid.

CCCXXXIV.

From the sparry fluor, by means of the vitriolic acid, may be expelled an air a good deal similar to that which is obtained from the vitriolic acid itself; but this sparry acid air has not yet been sufficiently examined.

CCCXXXV.

Vinegar, when strongly concentrated, yields, by mere boiling, an acid air, which must be collected by means of quicksilver, being immediately absorbed by water: it is called *acetous air*.

CCCXXXVI.

Oil absorbs it greedily, to the amount even of ten times its own bulk. The oil becomes thereby thinner as well as whiter, which is just the reverse of the effect produced on it by the mineral acids; these giving

giving it colour, and rendering it more tenacious than before.

CCCXXXVII.

The aërial acid bears a resemblance, in several respects, to the airs obtained from the acids mentioned above [see from 314 to 336]; but, on the other hand, it is not so quickly absorbed by water, and it precipitates the lime from lime-water; not to mention various other properties by which it differs from them. In the mean time, to judge from analogy, it seems very probable, that phlogiston is one constituent part of it [see 332]. But, although this fact should be put out of doubt by experiments, it would be no proof, but that this may be as much an air *sui generis*, as any other. Phlogiston may, in the most evident manner, be separated from marine acid; and the fact of their union may be demonstrated, as well by synthesis as by analysis, which is more than hath as yet ever been done with regard to the aërial acid.

acid. Notwithstanding this, it never surely entered into the head of any one, to refuse to the first-mentioned substance its peculiar place among the real acids.

CCCXXXVIII.

From caustic volatile alkali may also be obtained a kind of air by heat alone. This alkaline air must be collected by means of quicksilver; for it is absorbed by water, and is then not to be distinguished from a common alkaline solution.

CCCXXXIX.

When this air is applied to any of the acid kinds of air, the compound becomes visible in the form of a cloud, which afterwards concretes into saline crystals, which are in the nature of so many ammoniacal salts, according to the species of the acid. Nitrous and inflammable airs give but small signs of being affected by it; upon receiving it, however, with either of those airs, something like a precipitation may be seen.

CCCXL.

CCCXL.

A candle is extinguished in it; but at the moment of extinction the flame is enlarged, and becomes yellowish.

CCCXLI.

Ice melts in it very quickly, but oils do not absorb it.

CCCXLII.

When electrical shocks are transmitted through it, the space it occupies is increased by every shock. In this case, in proportion to the augmentation made in its bulk, its inflammability is increased, and its disposition to be absorbed by water is diminished.

CCCXLIII.

When all the several above-mentioned substances are thoroughly known, in regard
M to

to their composition, then, and not till then, will it be time to form just ideas respecting the elements themselves; and to attempt to give an answer to the question, whether all things are created out of one single element, or out of two, or other small and determinate number of elements? With respect to this, it may be worth while to observe, that because such or such a method appears to us, when considering it with reference to our own power, the easiest to pursue, we are not to conclude that this must necessarily be the method, of all others, that nature has actually pursued. Our business is, in the first place, to make sure of understanding the nature of bodies as they are; and then it will be time enough to set about enquiring from whence they may have derived their origin.

With Newton, then let us learn to ascend, by experiments and observations, from the phenomena to their real causes; and not, with Des Cartes, descend from fancied causes

causes to the phenomena; which, in that case, must always be tampered with and distorted, in order to force them into a coincidence with the preconceived hypothesis.

THE END.

E R R A T A.

- Page 18, Line 15, for *proportion*, read *proposition*.
p. 40, l. 7 and 9, for *it*, read *they*.
p. 69, l. 10, for *opipeiary*, read *opificiary*.
p. 74, l. 15, for *experiment*, read *experience*.
p. 133, l. 21, for *phlogisticated air*, read *foul air*.
p. 139, last line, read *consists not*.
p. 152, l. 5, for *accordingly forms with it*, read *forms with
it according, &c.*